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BULLETIN OF THE TORREY BOTANICAL CLUB
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TRIPLOID MUTANTS AMONG DIPLOID SEEDLING POPULATIONS OF ASIMINA TRILOBA[1]

WRAY M. BOWDEN[2]

The North American papaw, *Asimina triloba* (L.) Dunal, is an especially interesting species because it is the only member of the family Annonaceae that is hardy in New York, Michigan, and southern Ontario. The Annonaceae are mainly a tropical and subtropical family with a small number of species in the southeastern United States. Locke (10) observed $n = 9$ and Bowden (3, 4) determined $n = 9$, $2n = 18$ in *Asimina triloba*. Locke's counts were made from material collected near Mississippi State College and near Smith, Indiana; those of Bowden were made from the collection of papaw trees, from various sources, at The Blandy Experimental Farm, Boyce, Virginia. It seemed desirable to ascertain if there was any variation in chromosome number in populations of the species throughout its natural range. Requests for fruits and seeds were made in September, 1945 and 1946; twenty-three collections were received.

Material. The natural range of *Asimina triloba* is from New York State south to northern Florida, and from Nebraska to south-eastern Texas. The tree is rare in south-eastern Texas and northern Florida. Figure 1 shows the distribution of the collections examined as well as those studied by Locke (10). All material originated from wild plants except those from the trees cultivated at Geneva, New York. The southernmost part of the species range is not well represented. The collections from Michigan, southern Ontario, and New York, were from wild populations near or at the northern limits of the species range.[3]

[1] Contribution No. 939 from the Division of Botany and Plant Pathology, Science Service, Department of Agriculture, Ottawa.

[2] Assistant Botanist (Cyto-genetics).

[3] The collectors and localities from which the material was obtained are as follows; the numbers of seedlings examined cytologically are shown in parentheses. D: G. H. Hamilton; woods below Queenston Heights Park, Queenston, Lincoln County, Ontario (10). E: Dr. W. C. Coker; Chapel Hill, Orange County, North Carolina; (6). F: L. J. Gier; South of city limits of Liberty, Clay County, Missouri (6). G: Dr. F. A. Clarkson; through L. Van Kleemput; collected at Eighth Concession, Niagara Township, Lincoln County, Ontario; (3). H: R. A. Breuer; bluffs of Missouri River, Herman, Gasconade County, Missouri (6). I: Dr. G. L. Slate; Cultivated in papaw orchard, seed from best varieties, New York Agricultural Experiment Station, Geneva, New York; pkt. No. 1 (7). J: Same source as I: pkt. No. 2 (5). K: Mrs. E. J. Musseden; tree in orchard, Illiopolis, Sangamon County, Illinois (5). L: Miss P. E. Van Winkle; Shelbyville, Shelby County, Indiana (6). M: Miss A. Huber; Dubois Farm, near Wabash, Wabash County, Indiana (3). N: I. R. Hunter; five miles east of Dowagiac, Cass County, Michigan (7). O: Mrs. D. T. Ransdell; Lawrence, Douglas County, Kansas

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Methods. The seeds were separated from the pulp, placed in a sand-peat mixture in labelled pots, and transferred to cold storage for stratification for a period of about five months. Temperature was kept above the freezing point but low enough to obtain satisfactory stratification. The

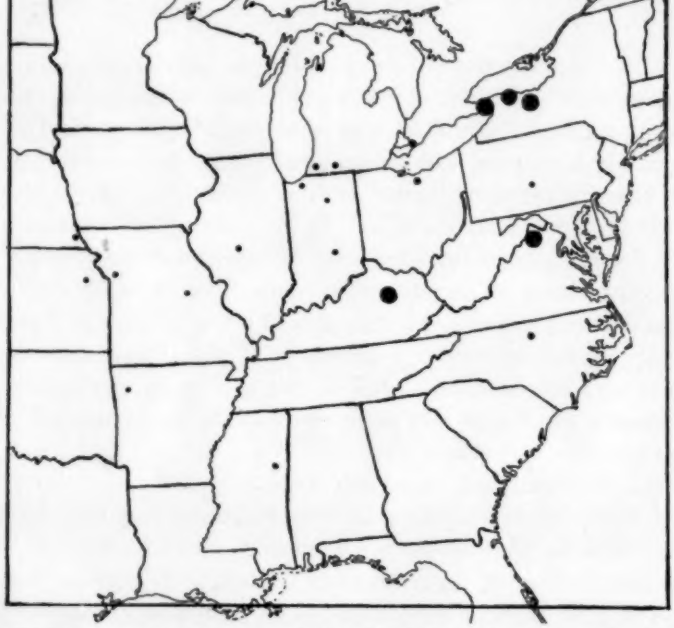


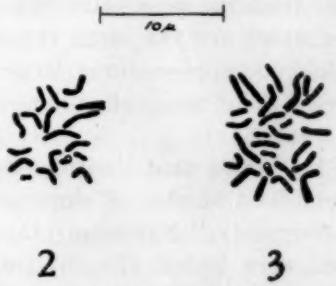
FIG. 1. Distribution of collections of *Asimina triloba*. Symbols: large dots—diploid populations with single triploid mutants; small dots—diploid populations. The collections reported in this paper are shown and the two collections of Locke (10).

seeds were removed from the cold cellar in March, repotted in a peat-soil mixture suitable for seedlings, and placed in the greenhouse. Several temperatures were tried; much better seedling growth was obtained in a warm house than in a cool one. The seeds germinated well in almost all of the

(4). P: Mrs. A. E. Shenk; farm of Jesse Ash, Quincy, Branch County, Michigan (4). Q: W. F. Brinker; near Spencer, Black River Valley, Medina County, Ohio (3). R: W. A. Smith; near Brockport, Monroe County, New York (4). S: D. M. Moore; near St. Paul, Madison County, Arkansas (3). T: Dr. F. T. McFarland; three miles west of Clay City, Powell County, Kentucky (9). U: A. A. Wood; from trees two miles south-east of Chatham, Kent County, Ontario (43 seedlings from 12 fruits). V: Mrs. E. G. Noble; Brownsville, Nemaha County, Nebraska (9). W: Dr. G. L. Slate; cultivated in papaw orchard, New York Agr. Exp. Stat., Geneva, New York (46 seedlings from 10 fruits from 10 trees). X: G. H. Hamilton, through Dr. W. S. Fox; near Queenston, Lincoln County, Ontario (4). Y: H. W. Copenhaver; above Front Royal, banks of Shenandoah River, Warren County, Virginia (10). Z: Dr. F. D. Kern; Colerain State Park, Spruce Creek, Huntingdon County, Pennsylvania (2).

collections. This satisfactory result was due to the freshness of the seeds and an adequate stratification period.

The seedlings were grown until an optimum level of mitotic activity was reached. Some of the seeds were slower in germinating or in producing active root-tips so that it was not possible to fix root-tips of all seedlings in each collection. Root-tips from all vigorous seedlings in each population were fixed in Belling's modification of Nawashin's fixative, embedded according to La Cour's alcohol-chloroform-paraffin schedule, sectioned at a thickness of 10 μ, and stained by La Cour's iodine-crystal violet schedule. In fixing the root-tips, improved fixation was obtained in some roots by cutting them longitudinally, and in others by removing the root-cap region before fixing. Most of the root-tips showed large numbers of metaphases in the most active mitotic region. The root-tips of each collection were embedded in groups with three or four root-tips in each series. This procedure was a great aid in reducing the amount of handling and the quan-



FIGS. 2 and 3. Camera lucida drawings of mitotic metaphases in periblem cells of root tips. FIG. 2. Diploid (2n=18) from seedling No. 2, population X, Queenston, Ontario. FIG. 3. Triploid (2n=27) from seedling No. 1, population X, Queenston, Ontario.

tity of materials required. Smear methods were tried on papaw root-tips, but were not satisfactory, although the same methods gave good results with *Crepis capillaris*, *Vicia Faba*, and *Trillium grandiflorum*. All examinations were carried out with an oil-immersion lens. The use of Wratten filter No. 60 (green) in combination with Wratten filter E No. 22 (deep orange) facilitated the observations. The drawings were made by use of a Spencer research microscope equipped with a 90 × oil-immersion objective, N.A. 1.30, and 12 × ocular.

Results. Somatic chromosome numbers were determined in root tips of 205 seedlings from 23 collections. Large numbers of metaphases were examined in all tissues of each root tip. In 18 collections, 171 seedlings were diploid ($2n = 18$). In collections I, R, T, X and Y, 29 seedlings were diploid, and 1 seedling in each was triploid ($2n = 27$). Thus, of 205 seed-

lings examined, 200 were diploids and 5 were triploids. The frequency of triploidy was 2.4 per cent or 1 triploid per 40 diploids.

The camera lucida drawings in figures 2 and 3 were made from plates that were chosen because chromosome morphology could be observed well in them. In many plates, a few of the chromosomes tended to lie close together and made interpretation difficult. There was also a tendency for the smaller chromosomes to lie obliquely or vertically so that a careful analysis of many plates was carried out before the drawings were completed. In a few plates, the nucleolus persisted to mid-metaphase. One or two small chromosomes were sometimes associated with the nucleolus and were seen to lie alongside it, often obliquely or vertically.

A comparison of figures 2 and 3 shows that the area of a triploid plate is larger than that of a diploid plate. All five triploid roots showed this greater plate area. Four of the triploid roots were comparable in size to the diploid roots. The triploid root from population X was larger than any of the three diploid roots from the same collection. In the diploid complement of *Asimina triloba*, there are two large chromosomes and two very small ones. In the triploid metaphase, three large and three very small chromosomes were observed. The range of chromosome size and morphology is shown in figures 2 and 3.

Discussion. Löve (11) stated that "within almost all plant species, individuals with an autotriploid number of chromosomes may be met with in nature in a very low frequency." Nawashin (15) examined 2,000 plants of *Crepis capillaris;* 1,989 were diploid ($2n = 6$) and 11 (0.55%) were triploid ($2n = 9$). Giles (5) studied 59 collections of *Cuthbertia graminea* and found 27 diploid plants, 1 triploid, 129 tetraploids, two hexaploids, and two aneuploids, that is, one triploid (0.62%) among 161 plants. Baldwin (1) examined 71 collections of *Sedum ternatum* and reported that 11 collections were diploid, 57 tetraploid, two triploid, and one was hexaploid; or 2.8% were triploids. Baldwin and Culp (2) found that seedlings grown from 7 collections of seeds from single-tree collections of *Diospyros virginiana* were tetraploid ($2n = 60$) and seedlings from 17 collections were hexaploid ($2n = 90$). Johnsson (7) selected twin, triplet, and quadruplet seedlings from more than 75,000 acorns of *Quercus robur*. Of these, 728 seedlings were diploid ($2n = 24$) and three (0.41%) were triploid ($2n = 36$). Müntzing (14) found that triploids were the commonest mutants in those twin seedlings which showed a deviating chromosome number. He observed that, in different species, there was a different frequency of chromosome number aberrants. Triploids occurred with high frequency in *Asimina triloba:* 200 diploids and 5 triploids, or 2.4 per cent triploids. The triploid mutants were not, however, distributed evenly in the populations; single

triploids were found in two populations with only four seedlings in each, while populations with 43 and 46 seedlings were all diploid. It is not known at present if any wild trees of *Asimina triloba* exist as triploid or possibly tetraploid individuals.

Triploids may arise in several different ways. De Mol (12) obtained unreduced pollen grains by digging unripe hyacinth bulbs and giving them a warm temperature treatment. The abnormal pollen was used to pollinate a diploid and 76 diploids and 3 triploids were obtained from the seed. Krug (9) summarized the work done on the subfamily Aurantioideae and found that more than 50 triploids have been observed in the genus *Citrus*. Some of these were produced by crossing diploids with tetraploids. About forty of the triploids were hybrids between diploid varieties and were thought "to have originated by non-reduction perhaps in megasporocytes." Müntzing (13) stated that "if an unreduced embryo sac is fertilized at the same time as the reduced one, the typical result will be obtained: one diploid and one triploid seedling." Two embryo-sacs may be present in the nucellus instead of one. He stated further that "if the twin plants differ in chromosome number, one of the twins is generally triploid in relation to the other one. This may be due to simultaneous fertilization of reduced and unreduced embryo sacs." Kostoff (8) suggested that triploids may develop from the endosperm. Ishikawa (6) observed the fusion of an egg nucleus with two male nuclei in *Oenothera*.

The triploid papaws occurred in areas where the temperature may have fluctuated considerably during the early spring season when meiosis was taking place in *Asimina triloba*. It is possible therefore that gametes from either unreduced pollen grains or unreduced embryo-sacs may have fused with normal reduced gametes to produce the triploids. If tetraploids occurred in the wild, it is obvious that they could have produced gametes with the two sets of chromosomes which, upon fusing with haploid gametes, would have formed triploid zygotes.

The author expresses his appreciation for the suggestions of Dr. Orland E. White, Director, The Blandy Experimental Farm, The University of Virginia, Boyce, Virginia; the aid of The Journal of Heredity and The Home Garden Magazine in collecting seeds; and the co-operation of collectors.

SUMMARY

Somatic chromosome numbers were determined in root tips of 205 seedlings of the North American papaw, *Asimina triloba* (L.) Dunal, that were grown from 23 collections of seeds. In eighteen collections, 171 seedlings were diploid ($2n = 18$). In five collections, 29 seedlings were diploid,

and 1 seedling in each was triploid ($2n = 27$). There was an average of one triploid per forty diploids.

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BULLETIN OF THE TORREY BOTANICAL CLUB
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THE SOMATIC CHROMOSOMES OF SARRACENIA

ADOLPH HECHT

The carnivorous aspects of the Sarracenias have been studied extensively, but the writer knows of only two papers in which any attention has been paid to the cytology of these plants. Shreve (1906) counted 12 chromosomes in the pollen mother cells of *Sarracenia purpurea*,[1] and Nichols (1908) reported this same count ($n = 12$) for *S. rubra* and *S. variolaris*.[2] Russell (1919) studied the anatomical characteristics of several species-hybrids of the genus, but made no chromosome counts. Lloyd (1942) reviewed the literature dealing with the general vegetative anatomy of the Sarracenias, but made no mention of cytological details. In Uphof's (1936) discussion of the genus in *Die natürlichen Pflanzenfamilien* the chromosome counts mentioned above are listed, but no additional studies are cited. Darlington and Janaki-Ammal (1945) list two species of *Sarracenia*, *S. drummondii* and *S. flava*, but with a blank in their column for chromosome number.

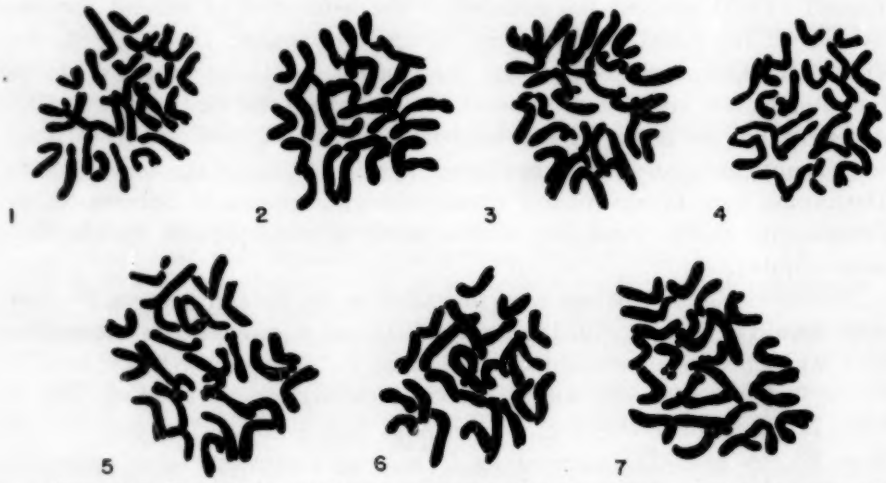
Six species of *Sarracenia* were identified in the flora of western Florida with the aid of Small's (1933) manual. These are *S. purpurea* L.,[3] *S. psittacina* Michx., *S. drummondii* Croom, *S. flava* L., *S. jonesii* Wherry, and *S. rubra* Walt. The present study involves these six species together with a form intermediate between *S. drummondii* and *S. flava*. The first five of these species and the intermediate form were commonly found growing together in low areas inland, whereas *S. rubra* was found only along the margins of bayous. Several other putative hybrids between these species were observed, and certainly would be expected where related species grow in such close proximity. That the species remain as distinct as they are in the absence of geographical barriers is even more remarkable. It was thought that chromosome counts together with studies of chromosome morphology might indicate the relationships of these species and serve as a basis for an understanding of the possible mechanisms of speciation.

Root tips collected from plants of these six species and the one putative hybrid were fixed in a Navashin's fixative and embedded in paraffin following an ethyl-alcohol–chloroform series. Transverse sections were cut at 15 μ, and stained in accordance with a modification of the iodine–crystal-violet technique. The root tips of *S. rubra* were collected along the bayou between

[1] Probably the northern variety, *S. purpurea* var. *gibbosa* (Raf.) Wherry.
[2] *S. variolaris* Michx. is now called *S. minor* Walt.
[3] The southern variety, *S. purpurea* var. *venosa* (Raf.) Wherry.

Valparaiso and Niceville, Florida; those of all of the other species and of the intermediate form were collected along Florida Highway No. 54, about three miles south of Crestview, Florida.

Karyotypes of root-tip metaphases are illustrated in figures 1–7. The chromosomes were drawn with the aid of a camera lucida at an initial magnification of 2825. The average diameter of each of the figures is approximately 11 μ. The $2n$ chromosome number proved to be 26 for all the material examined, but as the drawings show, the size and shape of the chromosomes provide little information concerning interspecific homologies. Although these counts do not agree with the two previous reports of chromosome numbers in *Sarracenia* cited above, it is entirely possible that



FIGS. 1–7. Karyotypes of root-tip metaphases of *Sarracenia*. FIG. 1, *S. purpurea*. FIG. 2, *S. psittacina*. FIG. 3, *S. rubra*. FIG. 4, *S. jonesii*. FIG. 5, *S. flava*. FIG. 6, *S. drummondii*. FIG. 7, putative hybrid of *S. flava* × *S. drummondii*.

this earlier work is also correct, that different collections of a single recognized species may differ in chromosome number. On the other hand, aneuploid differences between closely related species and varieties are rare. Nichol's (1908) drawings show that she missed a few of the 12 pairs in some of the metaphase figures; it is possible that one of the pairs was obscured in the figures which she thought were complete.

The material for the present study was collected during World War II while the writer was stationed at an army air base in northwestern Florida. Since he is now located far from that area it is hoped that the publication of these observations may suggest a more thoroughgoing study of the cytological features of the Sarracenias to someone now working in the region where these plants grow.

SUMMARY

The somatic chromosome number of *S. purpurea, S. psittacina, S. drummondii, S. flava, S. jonesii, S. rubra,* and of a putative hybrid of *S. drummondii* and *S. flava* was found to be 26. Previous counts for two of these species, *S. purpurea* and *S. rubra,* and a third not involved in the present study have been reported as $n = 12$.

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BULLETIN OF THE TORREY BOTANICAL CLUB
VOL. 76, NO. 1, PP. 10–11 JANUARY, 1949

A NOTE ON SARRACENIA

W. H. CAMP

The foregoing paper by Adolph Hecht on "The Somatic Chromosomes of *Sarracenia*" is of considerable interest to one working on biosystematic problems. In the second paragraph of this paper he states (and rightly) that it is not at all unusual to find a series of species of this group, as usually recognized, growing in the same area under fairly comparable conditions. In the same place intermediates and putative hybrids are noted; he adds: "That the species remain as distinct as they are in the absence of geographical barriers is even more remarkable." Since (as he modestly hints) these observations were made at a time when he was necessarily occupied with things of greater moment and so could not extend his investigations beyond a few localities, it will, I trust, be clearly understood that the following remarks are in no way intended as criticism of his observations. What he said about the apparent distinctness of these forms can be quite true in local areas. More extended observations doubtless would have led him to a somewhat different view of the "distinctness" of the Gulf Coast sarracenias.

My own work on various plant groups within this area was interrupted by the war; more recently it has been revived. In the Spring of 1948 I was studying the genic composition of certain plant populations along the Gulf Coast and, purely by accident, my itinerary included the localities mentioned by Hecht. Although my work was not directly concerned with the Sarracenias of the region, it would have indeed been difficult not to take considerable notice of these spectacular plants. The latest of these field studies, extending from the Florida east coast into Louisiana, gave opportunity to examine reasonably large populations of these plants.

On earlier excursions I had noted considerable variation; on the most recent trip the thing which renewed my interest in this group was the apparently large amount of genic introgression which had taken place between these various forms, not only locally but over a wide area. It was the *lack* of distinctness between these so-called species of *Sarracenia* which impressed me rather than the ease with which they could be separated. The number of named "hybrids" in this group is a hint that they are not genetically disjunct; and the series of subspecific "entities" recognized by various authors is further indication (as in so many other groups of plants) of the presence of an interlocked gene complex. With nothing reliable on

the cytology of this group available, it was impossible to proceed with any population studies beyond mere tentative observations.

It has become increasingly obvious that the taxonomy of a variable group containing a proportion of segregative polyploids must be approached in a different manner from that of one made up of homoploids capable of genic introgressions. As Hecht suggests, additional cytological study will be necessary to obtain a complete picture of the group. The great value of his preliminary paper lies in a demonstration of the homoploid condition of the series of materials on which his study was made; and these, apparently by accident, from what I consider to be one of the more critical areas. With this important information at hand, work now can proceed on the analysis of populations in this group by anyone interested with considerably greater assurance that the ultimate conclusions on its systematics will be sound. It is a great stride forward in our understanding of the rather complicated situation which one sees in the Gulf Coast Sarracenias as demonstrated by what we now have adequate reason to suspect is no more than a series of genic introgressions on the homoploid level.

THE NEW YORK BOTANICAL GARDEN
NEW YORK

BULLETIN OF THE TORREY BOTANICAL CLUB
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THE PROPAGATION OF KALMIA LATIFOLIA FROM SEED

WILLIAM FLEMER, III

Within the horticultural trade *Kalmia latifolia* L. is considered to be one of the most difficult plants to propagate from seed and attempts to utilize cuttings have been unsatisfactory. The thousands of plants of this species sold annually are pillaged from native woodland stands either as mature specimens or as seedlings requiring a subsequent period of culture in the nursery. A successful and practical method of propagation of *Kalmia* from seed would not only make this popular plant available at more reasonable prices but also would preserve it in its natural plantations.

Rayner's studies (4) on the significant role of root-fungi in *Calluna* and related genera and Barrows' investigations (1) on the endophytic fungus found in *Epigaea repens* L. indicate that a mycorrhizal association is an important factor in the physiology of the *Ericaceae* under natural woodland conditions. In view of this it seems evident that any successful technique for the propagation of *Kalmia* from seed, either in the laboratory or in the nursery, must include consideration of the role of the mycorrhizal fungus always found in the roots of the wild plants. Rayner also states that in *Calluna* (4) the endophyte is not restricted to the roots but extends to all parts of the plant as well. If this were also true of *Kalmia*, the seed presumably would carry the mycelium of the endophytic fungus, the mycorrhizal association would thus begin under natural conditions at seed-germination, and there would be no need to supply the root-endophyte to the cultures at the time of germination of the seed. Attempts to demonstrate the presence of a fungus within the integuments of the ovules were unsuccessful and immature embryos removed under sterile conditions and planted in a medium suitable for the culture of plant embryos developed beyond the seedling stage entirely free from any associated fungus. This fact was substantiated by the absence of any fungal associate in all plants in sterile culture derived from surface-sterilized seed. It is apparent, therefore, that the mycorrhizal endophyte must be supplied artificially to secure a normal growth of the young *Kalmia* plants in a culture medium not enriched with organic compounds and growth substances. Furthermore, attempts to propagate *Kalmia* from seed, even in nursery beds specially prepared with soil from native stands, are usually unsuccessful. Although such beds presumably contain the mycorrhizal fungus associated with *Kalmia*, before the association can be effected, competitive fungi pathogenic to *Kalmia* begin to operate. In such beds the loss of young

seedlings may be complete and as yet no uniformly successful method has been devised for carrying the seedlings through the critical young stages. The problem within the laboratory is obviously less difficult since methods based upon sterile technique can be employed. A laboratory technique for the propagation of *Kalmia* from seed necessitates (first) the isolation in pure culture of the endophytic fungus with which *Kalmia* is associated under natural conditions, (second) the selection of an enriched medium suitable for seed germination and for the subsequent growth of the seedling under sterile conditions, and (third) the establishment of the mycorrhizal relationship by the combination of the seedling and the fungus in a minimal medium. Such a technique then may be adapted to horticultural practice as in the case of the sterile culture of orchids from seed.

The Isolation of the Mycorrhizal Endophyte. In early October, specimens of *Kalmia*, ranging in size from seedlings to plants of flowering age, were collected from a number of localities in the vicinity of New Haven, Connecticut. Microscopic examination of the roots of these plants disclosed in all abundant hyphae sheathing the younger portions with frequent penetrations into the cortical cells. A number of young roots were rinsed in several changes of distilled water to remove all surface debris and then treated for ten minutes in a solution of calcium hypochlorite (6). The sterilizing solution used in this treatment, as well as later for the sterilization of the *Kalmia* seeds, consisted of equal parts of the commercial laundry bleach known as Clorox and water containing 5 drops of the detergent Aerosol (25%, O. T. Clear) to 100 cc. (2). The roots were then rinsed in several changes of sterile distilled water and plated out in standard petri dishes on Difco malt agar in two-thirds the prescribed concentration. In 4–5 days numerous fungal hyphae grew out from the surface of the roots and several days later these developed into mycelial growths of eight distinct types. The most frequently occurring type, which developed always later than the others, formed a somewhat dense, white felt of only moderately rapid growth. All eight types were isolated and maintained on the Difco malt agar medium in slant cultures at room temperatures, to be used later in the determination of the true endophyte.

The Culture of Sterile Seedlings. Mature seeds of *Kalmia*, collected in the late fall from various localities in the vicinity of New Haven, were freed from capsule-debris by screening and stored in closed containers in a refrigerator at 35° F. Numerous samples of these seeds were sterilized by the process described in connection with the isolation of the root-endophyte for periods ranging from 10 to 30 minutes. About 1 cc. of each sample of seed was placed in a small Erlenmeyer flask and covered with the "Clorox-

Aerosol'' solution. The flask was shaken gently to insure uniform action of the sterilizing solution. During this process it was observed that the seed containing well developed embryos settled to the bottom of the flask and that the chaff and aborted seed remained at the surface or in suspension. At the termination of the sterilization-period the ''Clorox-Aerosol'' solution together with the extraneous material was decanted off. The seed was rinsed twice in sterile distilled water, taken up in a sterile pipette of the medicine dropper type and then deposited in small amounts on an agar medium in small petri dishes. The seed was then spread uniformly over the surface of the agar with a sterile platinum loop. The medium selected for the germination and subsequent growth of the seedlings was that used for the culture of the *Kalmia* embryos. It is a modification of the medium for the culture of roots developed by Robbins and Schmitt (5) and later used by Burkholder also for the culture of roots and by Castle for the culture of small embryos of *Capsella*. In its modified form it has the following composition.

$Ca(No_3)_2 \cdot 4H_2O$ A.R.	0.4800 gm.
$MgSO_4 \cdot 7H_2O$ A.R.	0.0630
KNO_3 A.R.	0.0630
KCl A.R.	0.0420
KH_2PO_4 A.R.	0.0600
Trace elements in parts per million (B-1, Mn-1, Zn-7, Cu-2, Mo-1, Fe-5)	
Sucrose A.R.	20.0000
Thiamin	.0001
Niacin	.0005
Pyridoxin	.0001
H_2O distilled	up to 1 liter
Agar (Difco, Noble)	9.0000
pH adjusted to 4.8 with 0.1 N H_3PO_4	
Autoclaved for 15 minutes at 15 pounds of pressure.	

The cultures were maintained in a humidified chamber at 22° C and illuminated by two ''daylight'' 20-watt fluorescent lamps placed at a distance of 15 inches. Germination began in 9–10 days after sowing or about 2 weeks earlier than seed sown in specially prepared nursery beds. Seed treated for 10 minutes in the ''Clorox-Aerosol'' solution gave complete sterilization with a high percentage of germination and this period of sterilization was adopted for all subsequent seed treatment. Sterilization periods in excess of 20 minutes, however, resulted in progressively lower percentages of germination.

Vigorous seedlings showing the first true leaf were transferred to dishes containing freshly prepared medium. Subsequent transfers and replacements were made to provide a sufficient number of individuals of approximately uniform size and vigor for the study of the effect in a minimal medium of the combination with each of the eight fungi isolated from the

Kalmia roots. At the end of eleven weeks each of the selected seedlings had 6–7 leaves and a well developed root-system.

The Combination of the Sterile Seedlings and the Root Endophyte in a Minimal Medium. By means of sterile forceps the selected seedlings were transferred to 125 cc. Erlenmeyer flasks containing 50 cc. of the following medium.

NH_4NO_3	0.500 gm.
KH_2PO_4	0.200
$MgSO_4 \cdot 7H_2O$	0.400
$CaCl_2 \cdot 2H_2O$	0.130
Trace elements in parts per million (B-1, Mn-1, Zn-7, Cu-2, Mo-1, Fe-5)	
Agar (Difco, Noble), washed in 10 changes, 500 cc. each, distilled water	9.000
H_2O	up to 1000.000 cc.
pH adjusted to 4.8 with 0.1 N H_3PO_4	
Autoclaved for 15 minutes at 15 pounds of pressure	

Combinations with the fungi isolated from *Kalmia* roots were made by planting small tufts of mycelium in close association with the roots of each seedling. Eight series of five flasks, each flask containing eight seedlings, were inoculated in this manner with each of the eight fungi. An additional series of five flasks containing sterile seedlings was reserved without inoculation for comparison as controls. At the end of three weeks the inoculated seedlings exhibited marked differences when compared with those of the control series. In four series, through the pathogenic effect of the fungi the seedlings were either dead or in a dying cindition. In three others the plants appeared to be in good condition and some showed a slight increase in growth over that of the controls. In the single remaining series, however, the seedlings were not only larger than the controls but of a deeper green color, indicating a definitely beneficial effect from the association with that particular fungus isolate. It is significant, moreover, that this isolate was the one most frequently obtained from *Kalmia* roots after sterilization of the root surface. At the end of three months these plants were 3–4 times larger than the controls and had maintained the deeper green color.

At this time the entire root system of one plant from each flask of this series was washed, fixed in a combination of chromic and acetic acids of medium strength, and stained with Orseillin BB and Crystal Violet according to the technique of Cohen and Doak (3). The preparations showed abundant hyphae on the root surface and frequent hyphal connections with mycorrhizal coils within the cortical cells. Microscopic observation of subsequent combinations of this fungus with *Kalmia* seedlings in a minimal

medium showed that extensive penetration of the mycorrhizal associate usually did not occur during the first three or four weeks of the association of the seedling and the endophyte. The remaining seedlings were then transferred to small pots containing a mixture of loam, sand and humus to which was added peat moss in sufficient quantity to secure the low soil pH required by *Kalmia*. The plants quickly became established and, after a month of growth in the open pots in the greenhouse, were upon an average approximately three times larger than the few *Kalmia* seedlings of comparable age surviving in seed-beds in the nursery.

SUMMARY

1. All roots of wild *Kalmia latifolia* examined showed the presence of mycorrhizal fungus both endotrophic and ectotrophic.

2. The mycorrhizal associate has been isolated and grown on a synthetic medium.

3. Sterile seedlings have been grown through early stages in a synthetic medium enriched with sucrose and growth substances.

4. The sterile seedlings when combined with the fungal associate on a minimal medium rapidly outgrew controls as well as seedlings of a comparable age which survive in nursery beds.

5. The results suggest the possibility of perfecting a culture technique for *Kalmia latifolia* comparable with the technique commonly employed for orchids.

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A REINVESTIGATION OF THE EMBRYO SAC OF MAIANTHEMUM CANADENSE

B. G. L. SWAMY

McAllister's (1914) report of the occurrence of an Adoxa type of embryo sac in *Maianthemum canadense* was taken for granted to be the true situation until Stenar (1934) found the Drusa type of development in *M. bifolium*. This conflict of reports for *Maianthemum* and the fact that in recent years several of the alleged Adoxa types are proving to be different upon reinvestigation, urge a restudy of *M. canadense* (see also Maheshwari 1947a). The material for the present investigation was collected from the Arnold Arboretum of Harvard University.

The dyad nuclei resulting from the first meiotic division in the megaspore mother cell are separated by a wall (fig. 1). The second division results in four megaspore nuclei, each separated by a wall (figs. 2–4). The arrangement of the megaspores of the tretrad in the majority of ovules is tetragonal (figs. 2, 3) whereas a linear condition (fig. 4) is rather rare. In either case, the walls separating the megaspores are only transitory, and after a time the four nuclei lie in the common cytoplasm, enclosed by the original wall of the megaspore-mother cell (fig. 5).

Whatever is the type of arrangement of the megaspores in a tetrad, the nuclei become disposed in 1 + 3 arrangement before the next division (fig. 6). As a result of a simultaneous division of all the four nuclei (fig. 7), a 2 + 6 arrangement of the nuclei becomes established at the 8-nucleate stage (fig. 8). One more division of these nuclei (fig. 9) results in a 16-nucleate embryo-sac (fig. 10), with an egg apparatus of two synergids and an egg cell, 11 antipodal cells, and two polar nuclei.

It must be mentioned at this point that the number of antipodal cells frequently is less than eleven. In a small percentage of the sacs, this is brought about by the failure of division of one or more of the chalazal nuclei at the 2 + 6-nucleate stage, a situation comparable to that in *Ulmus* (D'Amato 1940; Ekdahl 1941). However, the predominant method of reduction in the number of antipodals is their very early degeneration. The antipodal cells at the farthest chalazal end appear to degenerate and disappear sooner than those that lie nearer to the center of the sac. In other words, the antipodals situated towards the interior of the sac are the last to suffer degeneration. As a result of these two phenomena (failure of division of the chalazal nuclei and early degeneration of antipodals) the embryo-sac at anthesis contains less than 16 nuclei. Although the number

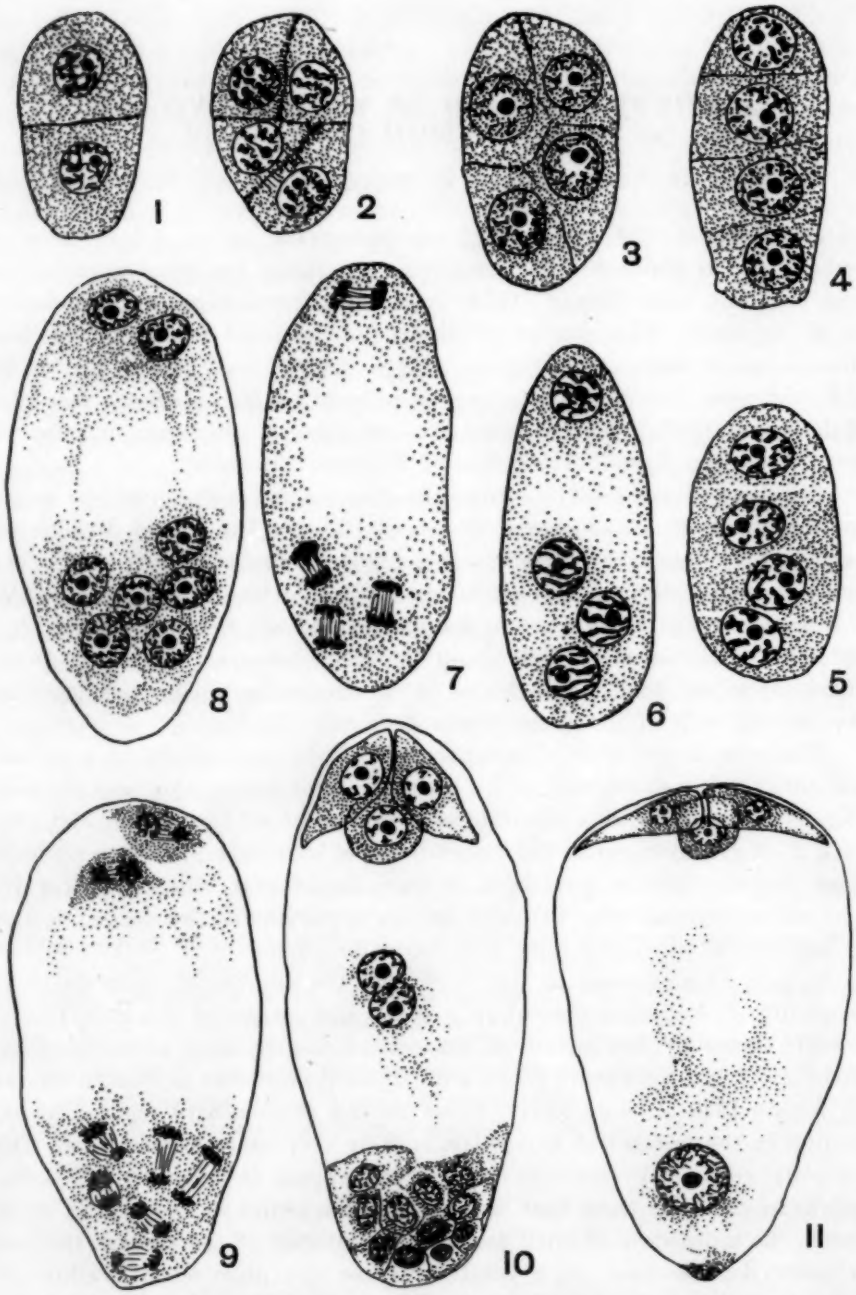

FIG. 1. Dyad stage. FIGS. 2–4. Tetrad stage. Note the transitory walls between the megaspore nuclei. FIG. 5. A linear tetrad after the dissolution of the walls separating the nuclei. FIG. 6. 1+3 arrangement of the megaspore nuclei. FIG. 7. Division of the megaspore nuclei. FIG. 8. 2+6-nucleate stage. FIG. 9. Final division of the gametophytic nuclei. FIG. 10. 16-nucleate embryo-sac soon after its formation. FIG. 11. Embryo-sac in which the antipodal cells have degenerated. All figures, ×560.

of the persisting antipodal cells fluctuate widely—anywhere between 1 and 11—the most frequent range is between 2 and 4. Particularly in those embryo sacs that failed to receive the pollen tube at the right time, the only persisting structures are the egg apparatus and the secondary embryo-sac nucleus (fig. 11). This situation helps us to understand how McAllister overlooked the fundamental 16-nucleate nature of the embryo sac in *M. canadense*.

Of 373 embryo sacs examined, the development in 322 followed the method just described. In the remaining 51 the procedure is different. During the division following the 2 + 6-nucleate stage of the gametophyte (fig. 12), the metaphase spindles at the chalaza fuse in pairs, thereby resulting in six diploid nuclei at the corresponding end (figs. 13, 14). Although actual counting of the chromosomes on these spindles has not been possible, a complete series of stages in the derivation of the diploid nuclei has been observed. Furthermore, there are other evidences for the diploid condition of the chalazal nuclei: the larger breadth of the chalazal spindles during the early stages of fusion as compared with those of the micropylar end (fig. 12); the corresponding relation maintained by the resulting nuclei during the telophase of the same division (fig. 13); the larger size of the chalazal nuclei each containing two distinct nucleoli, as compared with the smaller nuclei each with a single nucleolus at the micropylar end; the richer accumulation of chromatin material of the chalazal nuclei in contrast to the micropylar group after the division (fig. 14). One of the diploid nuclei functions as the antipodal polar nucleus (fig. 15). Under these circumstances, the mature embryo-sac is 10-nucleate—four haploid nuclei at the micropylar end and six diploid nuclei at the chalazal end. The antipodals organize into cells as in the typical 16-nucleate sac.

This second type of development is particularly interesting. That the Drusa and Fritillaria types occur in the same species in varying proportions is especially revealed in *Tamarix* (Battaglia 1941). In *T. africana*, Battaglia finds the Fritillaria type in 43 per cent of the ovules and the Drusa type[1] in 57 per cent. That these two types are closely related is becoming increasingly evident (see Maheshwari 1947 a, b). In *T. africana*, the commoner Drusa type of development switches over to the less common Fritillaria type at the 1 + 3-nucleate stage and the resulting chalazal nuclei are triploid. On the other hand, in *M. canadense*, the fusion is carried over to the 2 + 6-nucleate stage and as the spindles fuse in pairs, the resulting nuclei are diploid. Although this situation may not strictly fall within the true Fritillaria type, the general trend of the process is obviously similar, and therefore may still be looked upon as a variant of the Fritillaria type.

[1] Battaglia refers these to the Pyrethrum type; however, I am in agreement with the views expressed by Maheshwari (1947 b, p. 19) in amalgamating this with the Drusa type.

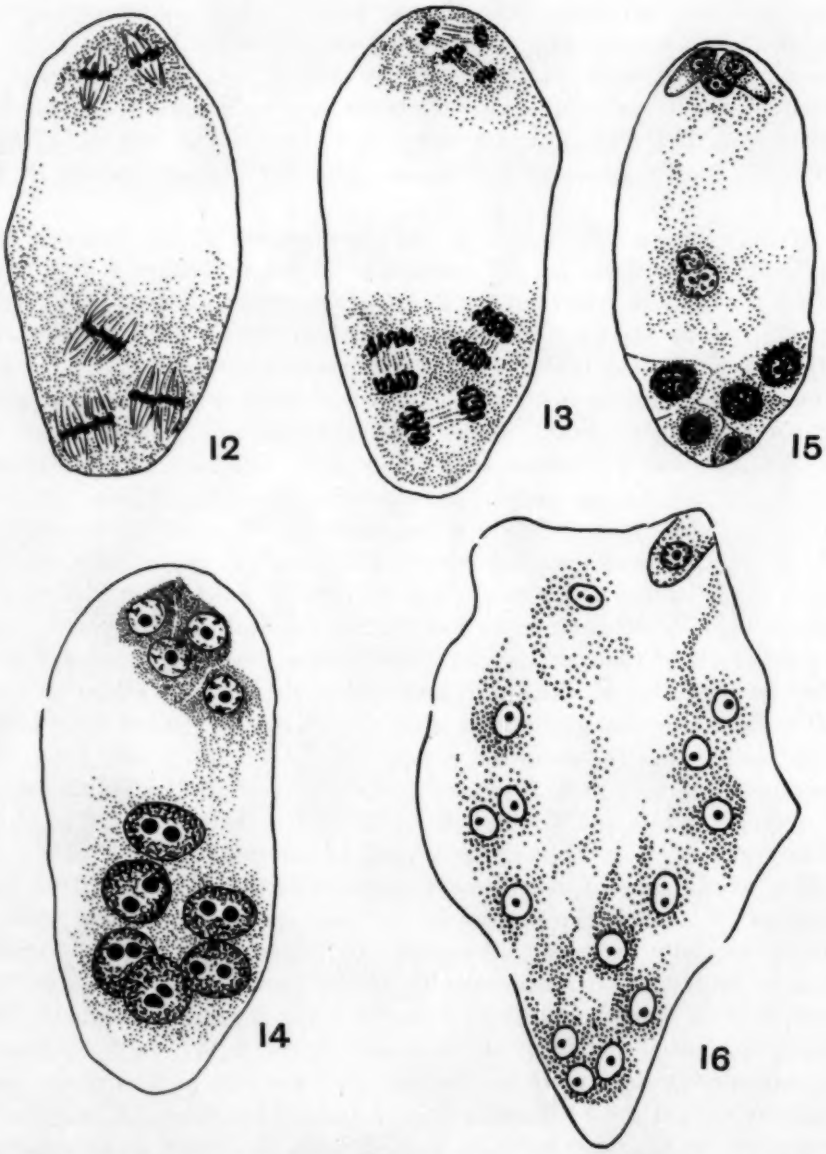

FIG. 12. Metaphase during the division of the nuclei following the 2 + 6-nucleate stage. Note the chalazal spindles fusing in pairs. FIG. 13. The same, telophase. Note the larger size of the nuclear masses on the chalazal spindles. FIG. 14. Slightly later stage than in figure 13. The four haploid nuclei at the micropylar end are organizing into the egg apparatus and the polar nucleus of the corresponding end and the six diploid nuclei at the chalazal end are not yet differentiated as cells. FIG. 15. Mature organization of the embryo-sac following the stage depicted in figure 14. FIG. 16. Zygote and free nuclear endosperm. Figs. 12–15, × 560; Fig. 16, × 300.

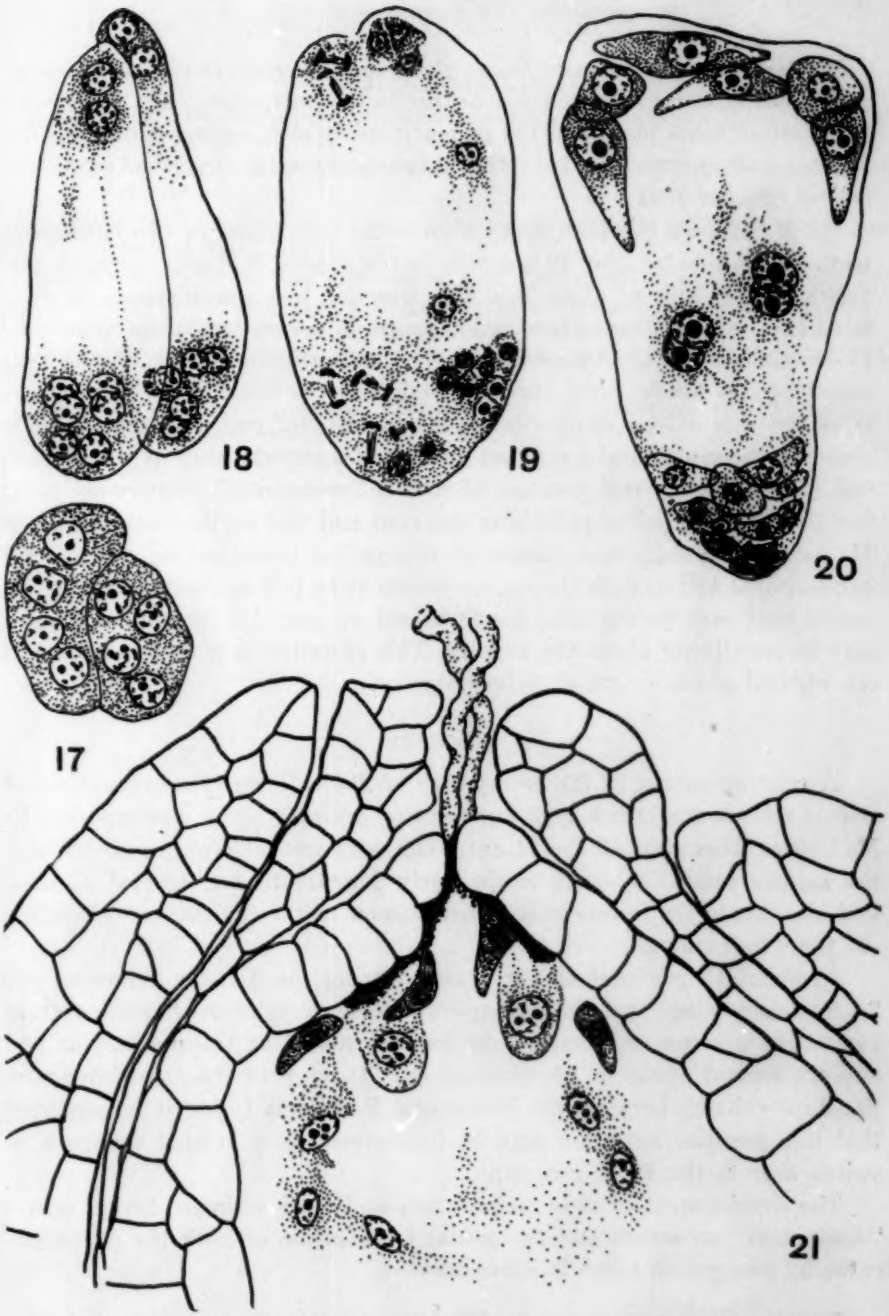

FIG. 17. Twin tetrads. FIG. 18. 2 + 6-nucleate stage in twin gametophytes. FIG. 19. Final division of the nuclei in one gametophyte and the beginning of organization of the nuclei in the other. The contiguous walls of the gametophytes are broken down. FIG. 20. Mature "compound" embryo-sac. FIG. 21. Post-fertilization stage of an embryo-sac as illustrated in figure 20, showing the integuments, the entry of two pollen tubes, the persistence of four synergids, two zygotes, and free nuclear endosperm. Figs. 17–20 × 560; Fig. 21, × 300.

In the fully mature embryo-sac, the secondary embryo-sac nucleus characteristically occupies a position nearer to the antipodals (fig. 11). Double fertilization takes place and the primary endosperm nucleus builds up free nuclear endosperm (fig. 16). The same condition is described in *M. bifolium* (Stenar 1934).

In *M. bifolium* Stenar (1934) records the occurrence of two megaspore-mother cells side by side. This occurs in the species studied at present also. Furthermore, both of them undergo more or less simultaneous development and develop into mature embryo-sacs, following the Drusa type (figs. 17–19). After the 2 + 6-nucleate stage, the contiguous walls of the twin gametophytes break down (fig. 19) and thus the resulting structure contains two sets of egg apparatus at the micropylar end, two sets of polar nuclei in the center and a varying number of antipodal cells at the chalazal end (fig. 20). Only one instance of such a "compound" embryo-sac being fertilized by two pollen tubes was observed and this is illustrated in figure 21. As there is definite evidence of two pollen tubes having entered the gametophyte and as both the zygotic nuclei show two nucleoli, it is to be assumed that each pollen tube has fertilized an egg. All the four synergids may be seen lying about the zygotes. This situation is a clear example of one method of the origin of polyembryony.

SUMMARY

A reinvestigation of the embryo-sac of *Maianthemum canadense* shows that it follows the Drusa type but not the Adoxa type as was reported by McAllister. However, all the 11 antipodal cells are not often in evidence at the mature condition owing to the early degeneration of several of them and also due to the failure of division of some of the chalazal nuclei during the preceding stages.

In about 13 per cent of the ovules, during the division following the 2 + 6-nucleate stage, the chalazal spindles fuse in pairs so that the mature gametophyte comes to possess four haploid nuclei at the micropylar end and six diploid nuclei at the chalazal end. In view of the close inter-relationships existing between the Drusa and Fritillaria types, it is suggested that this peculiar variation may be interpreted as a belated tendency to switch over to the Fritillaria type.

The development of twin embryo-sacs and their ultimate fusion into a "compound" structure and the actual fertilization of both the egg apparatus by two pollen tubes is demonstrated.

I express my appreciation to Miss Charlotte S. Pratt for the help she rendered in the preparation of this paper.

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CORDYCEPS BICEPHALA BERK. AND C. AUSTRALIS (SPEG.) SACC.[1]

E. B. MAINS

Recently several collections of a *Cordyceps* infecting ants were received from Liberia from J. T. Baldwin, Jr. who states that it is a common parasite there, killing ants by the thousands in the Western Province. The specimens have clavae which are bicolored, dark purplish-brown below and light brownish-yellow to cream-colored above. The stipes are slender and are terminated by ovoid to ellipsoid heads. Most of the clavae are simple (figs. 3, 4). In one specimen (fig. 1) the stipe is furcate and two heads were formed. The perithecia are entirely embedded in the head and are oblique, overlapping each other upward (fig. 2). In many collections the infected insects are attached to stems of plants, gripping them with their mandibles and legs.

Several species of *Cordyceps* on ants have been described with bicolored clavae. *Cordyceps proliferans* P. Henn. on an ant from South America is illustrated (3) as having furcate clavae, cylindric heads, and ovoid perithecia embedded at right angles to the surface of the head. The asci are described as cylindric-clavate, 150–180 × 4–5 μ. Hennings (4) also described another bicolored species, *C. Huberiana*, on an ant from South America. The clavae apparently are simple, the fertile portions cylindric, 8–9 mm. long and 1 mm. thick, the perithecia oblong, completely embedded, and the asci cylindric, 150–200 × 5–6 μ. The furcate condition of the clavae appears to be the principal distinction between *C. proliferans* and *C. Huberiana*. As Petch (12) has concluded, they apparently are the same species. The Liberian collections differ in the ovoid to ellipsoid heads, the oblique perithecia, and much longer asci.

Cordyceps necator was described by Patouillard and Hariot (10) as having bicolored clavae on ants from French Guinea. The specimens were immature and information is not available concerning the perithecia and asci. The application of the name is uncertain.

In 1882 Spegazzini (15) described a bicolored *Cordyceps* on an ant from Brazil under the name *Cordyceps* (*Torrubia*) *unilateralis* Tul. *australis* Speg. In 1883 Saccardo (14) raised it to specific rank. The fertile portions of the clavae are described as elliptic-subglobose or subovate, the perithecia

[1] Paper from the Herbarium and the Department of Botany of the University of Michigan.

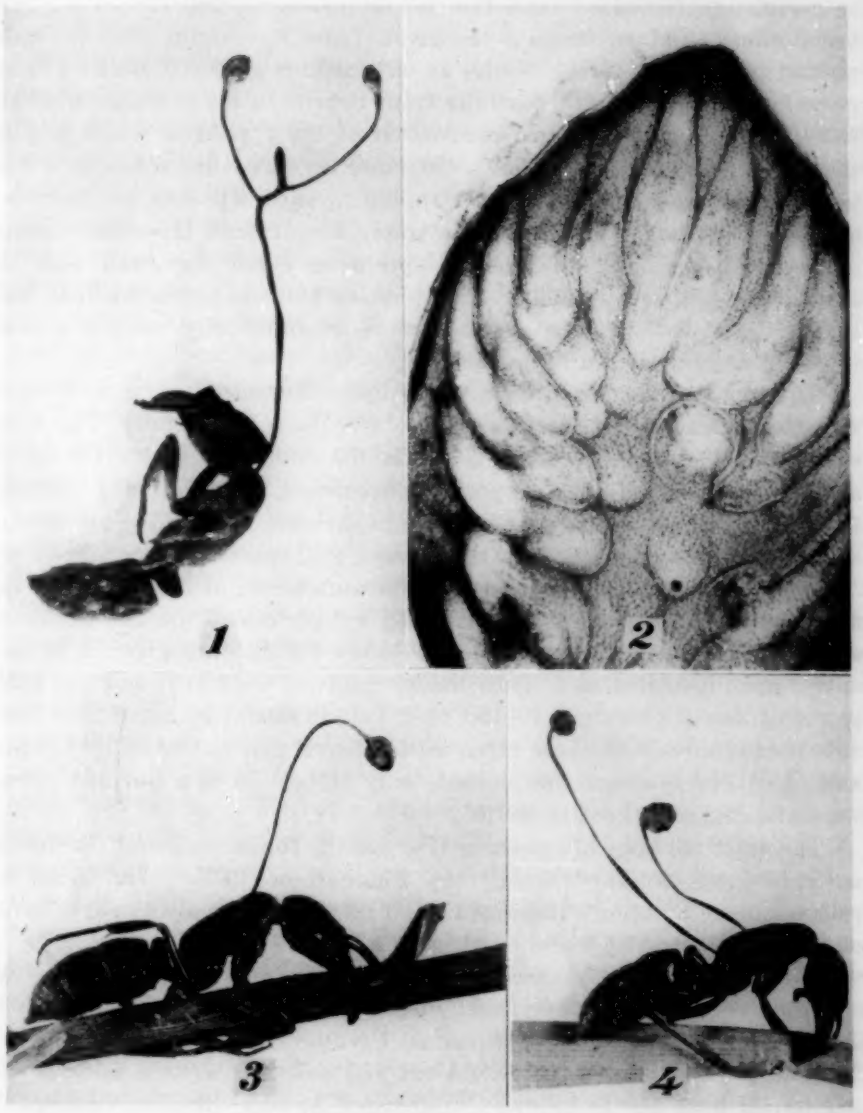

FIG. 1. Ant with a furcate clava of *Cordyceps australis* terminated by 2 heads, collected by J. T. Baldwin Jr. (*10480*), Western Province Liberia. × 3. FIG. 2. Longitudinal section through a head of *Cordyceps australis* showing the oblique, overlapping perithecia. × 45. FIG. 3. Ant with a single clava of *Cordyceps australis* arising from the thorax, collected by J. T. Baldwin Jr., Western Province Liberia Dec. 1947. × 3. FIG. 4. Ant showing two clavae from the same collection as 3. The bicolored condition of the clavae does not show due to printing to obtain contrast with the background.

as completely embedded, and the asci as cylindric, 240–250 × 4–5 μ. The orientation of the perithecia is not given. Later Spegazzini (16) again described the species, giving beetles as well as ants as hosts. Möller (9) reported a *Cordyceps* as *C. australis* from Brazil. In his description of the collections he emphasized the orientation of the perithecia which are described as flask-shaped, 650–750 × 250 μ and arranged like scales in a cone i.e. oblique to the surface and overlapping upward. The asci are described as up to 700 μ long, which is considerably longer than the measurements given by Spegazzini. The Liberian specimens agree very well with the description as given by Möller. The question however arises whether Möller's material is *Cordyceps australis*, since he apparently had not studied the collections described by Spegazzini.

Through the kindness of Juan C. Lindquist the collections in the Spegazzini Herbarium of *Cordyceps australis* were loaned for study. The outer envelope containing specimen 1768 has the following data "*Cordyceps unilateralis australis* Speg. Typus! *Pachycandyla striata* Apiahy (Brasil) leg. Puiggari". An inner envelope bears sketches apparently by Spegazzini of a section of a head, perithecia, asci, and spores. The perithecia are drawn as oblong, slightly oblique, and measurements of 500–600 × 100 [μ] are given. The asci are drawn as narrowly cylindric with the wall thickened at the apex, and measurements of 400–450 × 7–8 [μ] are given. The asco spores are illustrated as filiform, multiseptate, 250 × 2 [μ], and the part-spores as fusoid cylindric, 10–15 × 1½–2 [μ]. It should be noted that these data do not agree with those given in the description published by Spegazzini (15). The specimen now consists only of portion of a purplish-brown stipe attached to a curculio beetle.

The outer envelope of specimen 1769 has the following data "*Cordyceps australis* Speg. Apiahy (Brasil) leg. Puiggari no. 2335." The inner envelope has the notation "immatura" and now contains only two fragments of purplish-brown stipes and portions of a beetle.

The outer envelope of specimen 1770 bears the following data, "*Cordyceps australis* Speg. Apiahy (Brasil) leg. Puiggari." On the inner envelope is written, apparently by Spegazzini, *Cordyceps unilateralis* Tul. (sub *Torrubia*) with *unilateralis* crossed out and *australis* written underneath. Additional data are as follows "in formica Apiahy, Brasilia meridionali leg. Puiggari." There are also the notations "(+ *Cordiceps curculionum ?*)" and "an *C. bicephala* Berk.?" There are several sketches. One shows a clava with a slender stipe arising from between the head and thorax of an ant and terminating in an ovoid head. About half way on the stipe is a lateral globoid swelling. The asci are shown as cylindric with measurements 240–250 × 4–5 [μ]. The part-spores are cylindric, rounded at the ends, with measurements 5–10 × 1 [μ]. The data and sketches agree closely

with the description as first published by Spegazzini (15). It seems fairly certain that no. 1770 is the type specimen of *Cordyceps australis* (*C. unilateralis australis*). The envelope contains fragments of both ants and beetles. There are several fragments of stipes which are dark purplish-brown below and brownish- or reddish-yellow above. One stipe has a lateral sterile swelling like that shown in the sketch. Only one head occurs in the collection and it is glued to a piece of paper. A portion had been removed. It apparently was narrowly ellipsoid, 2×1 mm. It was possible to remove a few perithecia for study. The perithecia are conoid, $770–880 \times 230–250\ \mu$. They are arranged obliquely, overlapping upward. The asci are narrowly cylindric, 4–5 μ wide and up to 600 μ long. The wall of the ascus is thickened at the apex up to 4–5 μ. The ascospores are filiform, multiseptate breaking into fusoid-oblong, one-celled fragments, $8 \times 1.5\ \mu$.

Both no. 1768 and 1769 are *Cordyceps curculionum* Tul., a parasite of beetles. It is not surprising that Spegazzini included the fungi on ants and beetles under one species since they are very similar and evidently closely related. *C. curculionum* has bicolored clavae, ovoid to ellipsoid heads, oblique perithecia entirely embedded and overlapping upward, and cylindric asci, $400–480 \times 6–8\ \mu$. *C. curculionum* is somewhat more robust than the fungus occurring on ants and the asci are wider. The differences are not great and a specific separation may well be questioned. However for such parasites it seems logical to recognize specific separations based on the parasitism of two such distinct host groups as the beetles and the ants. The question whether the name *Cordyceps australis* should apply to the beetle or ant fungus is difficult to answer. If Speg. Herb. no. 1768 labeled Typus is considered the type, the name applies to the beetle fungus on the basis of the data on the inner envelope and what is left of the specimen. If so, it would become a synonym of *C. curculionum*. However, as has been pointed out, Speg. Herb. no. 1770 apparently is the type of *C. australis*. The occurrence of both beetles and ants in the packet indicates that both fungi may have been included in the original description. The specimens are in fragments and it is impossible to determine host connections. However the data obtained from the only head left in the collection indicates that it belongs to the ant fungus since it contains narrow asci. Also the sketch made by Spegazzini shows the fungus arising from an ant and the data he gives apparently were obtained from the ant fungus. It therefore seems safe to conclude that the name *C. australis* should be applied to the species on ants. With this interpretation the Liberian collections are *C. australis*.

Spegazzini (16) described another bicolored species on ants *Cordyceps goniophora*. Petch (13) has considered this a synonym of *C. Humberti*. A study of the type (Herb. Speg. 1779) has resulted in the conclusion that it is an immature specimen of *C. australis* in which poor conditions for growth or injury to the stipe have resulted in abnormal development of the clavae.

Spegazzini (15), following his description of *C. unilateralis australis*, raised the question whether it might be *C. bicephala*, Berk. Berkeley (1) describes the single clava as brown and furcate with two elliptical heads. The host is not given and probably was not collected. Cooke (2), Massee (8), and Lloyd (6) have discussed the species, apparently entirely from the type specimen. The orientation of the perithecia is not described and the only indication of a bicolored condition is Massee's statement that the stem is brown, paler upward. Petch (11) has concluded that *C. australis* is a synonym of *C. bicephala*. In his discussion of the species, he describes a bicolored condition but does not give the orientation of the perithecia. It is not clear how much of his data are derived from the type and how much from later collections which were determined as *C. bicephala*.

In answer to a request for information concerning the type in the Kew Herbarium Miss E. M. Wakefield writes that the type specimen of *C. bicephala* now consists of a single stalk forked at the top, originally bearing a head on each branch. Only one head is still attached. The other has been used for examination and is included in a small packet. The stalk is dark brown to black below. The upper part of the stem and the branches are buff or alutaceous. She loaned a slide having sections of the detached head. The perithecia were found to be conoid, 580–630 × 160–200 μ, and arranged obliquely, overlapping upward. It was not possible to distinguish asci and ascospores. This would support the decision of Kabayasi (5) that the name should be excluded as based on an immature specimen. Berkeley (1) describes asci stating that they are linear with clavate tips and the spores as very slender and linear. Massee (8) gives the asci as cylindric and capitate and the spores as linear 70 × 1 μ, multiseptate and the cells as 3 μ long. His measurements do not agree with those of *C. australis*. It seems doubtful whether the name *C. bicephala* can be used with certainty. A tendency toward a bicephalate condition has been noted for the ant fungus by Spegazzini, Möller, and Petch and one of the Liberian specimens shows it. However, furcate clavae occasionally occur in a number of species of *Cordyceps*. With the host unknown and data concerning the asci and ascospores insufficient it is not possible to determine whether the name *C. bicephala* should apply to *C. australis* or *C. curculionum*. It therefore seems best to consider it of doubtful application. The objection can be raised that *C. australis* was based on a mixed collection. The evidence indicates that the description was based on the ant fungus and therefore it is accepted instead of proposing a new name which otherwise would be necessary. The following description is based on collections from the Farlow Herbarium, Harvard University,[2] the

[2] The writer is indebted to Rolf Singer and W. Lawrence White of the Farlow Herbarium, D. P. Rogers of the Herbarium of the New York Botanical Gardens and Juan C. Lindquist of the Museo de la Plata for the loan of specimens for this study.

Herbarium of the New York Botanical Garden, the Spegazzini Herbarium, and the Herbarium of the University of Michigan.

CORDYCEPS AUSTRALIS (Speg.) Sacc. Syll. Fung. **2**: 571, 1883. *Cordyceps unilateralis australis* Speg. An. Soc. Cien. Argent. **13**: 215, 1882. *Cordyceps goniophora* Speg. Bol. Acad. Nac. Cien. Cordoba **11**: 540, 1889.

Clavae one or two arising from the thorax of an ant, simple or occasionally furcate, 10–25 (65) mm. long, the stipes very slender 0.2–0.3 mm. thick, dark purplish-brown to brownish-black below, light yellowish-brown to cream-color in the upper one-third, probably some shade of red when fresh, occasionally producing short sterile side branches or equally branched with terminating heads, capitate, the heads ovoid, ellipsoid or obovoid, 1.5–3 × 0.5–1.8 mm. smooth to somewhat rugose in the lower part, punctate from the ostioles of the perithecia, concolorous with the upper part of the stipe; perithecia entirely embedded, oblique, overlapping upward, conoid, 720–960 × 230–336 μ; asci cylindric, 500–720 × 4–5 μ, the wall thin, thickened over the apex, 4–6 μ, the ascospores filiform, multiseptate, breaking into one-celled part-spores, fusoid-cylindric, slightly narrowed and rounded at the ends, 6–10 × 1–1.5 μ.

On several species of ants.

BRAZIL: Apiahy, *J. Puiggari*, (Herb. Spegazzini 1770); Apiahy, *J. Puiggari*, 1881, (Herb. Spegazzini 1779); Tijuca, vicinity of Rio de Janeiro, *J. N. Rose & P. G. Russell*, (N. Y. Bot. Gard. 21192). BRITISH GUIANA: Tumatumari, Sept. 19, 1923, *D. H. Linder 210* (Farl. Herb.); Tumatumari, Sept. 20, 1923, *D. H. Linder 211* (Farl. Herb.); on *Paraponera clavata*, Bartica, Dec. 9, 1923. *D. H. Linder* (U. Mich.). LIBERIA: Gbanga, Sept. 15, 1926, *D. H. Linder*, (Farl. Herb.); Gbanga, September, 1926, *D. H. Linder 270 A*, (Farl. Herb.); Gbanga, September, 1926, *D. H. Linder 395*, (Farl. Herb.); Banta, 1939, *G. W. Harley* (Farl. Herb.); Zui, Western Province, Nov. 11, 1947, *J. T. Baldwin Jr. 10480* (U. Mich.); route Belleyella—Kondessu—Zui—Genne, Western Province, Dec. 1947, *J. T. Baldwin Jr.* (U. Mich.); Bonata, Central Province, Dec. 8, 1947, *J. T. Baldwin Jr.* (U. Mich.).

TYPE specimen on *Pachycondyla striata*, collected by J. Puiggari, Apiahy Brazil (Herb. Speg. 1770), Museo de la Plata, Argentina.

According to Petch (11) the conidial stage of *C. australis* was found on specimens collected by Paul W. Richards in British Guiana. It may arise as a branch of the perithecial clava or as an independent linear clava. He considers it to be the same as *Isaria melanopus* Speg. and states that it belongs in *Hymenostilbe*. He makes the transfer proposing the name *Hymenostilbe melanopoda* (Speg.) Petch (*H. melanopus* Mains, 7). Spegazzini (16) described *Isaria melanopus* from a collection on beetles and suggested that it was the conidial stage of *Cordyceps australis*. However, as has been pointed out Spegazzini considered that *C. australis* occurred on both ants and beetles. Since *C. australis* on ants is recognized as a separate species from *C. curculionum* on beetles it would follow that *Isaria melanopus* is probably the conidial stage of the latter species. According to Petch the conidial stage of *C. australis* of Richard's collections has phialides which are ovoid, minutely verrucose at the apex, 7–9 × 4 μ, with a short

central truncate sterigma and conidia which are hyaline, fusoid, with a truncate base, 7–9 × 1 μ.

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NEW SPECIES OF PUCCINIA ON LAURACEAE FROM CHINA[1]

GEORGE B. CUMMINS[2]

The rusts reported below form a closely related series of species. The relationship is so close that it is difficult in some cases to decide specific limits.

It is essential that the telia be studied in section, since the species are divisible into three main groups depending upon the diameter of the sorus and its position relative to the tissues of the leaf. In the first group the telia are cup-shaped, with a diameter of 60–100 μ, and are seated next the palisade layer, thus deeply within the leaf tissue. In the second group the telia are likewise seated next to the palisade layer but have a diameter ranging from 100–175 μ. Measurements are given for the sorus proper since the spores, when extruded, overspread the leaf surface as a pulvinate cushion much exceeding the diameter of the sorus within the leaf. In the third group the sori are merely subepidermal, thus neither cup-shaped nor deep-seated, and usually exceed 200 μ in diameter. Here again, the spores overspread the leaf. Superficially, the sori of all groups appear to be similar and the exposed mass of spores is 0.5–1.0 mm. in diameter.

Part of the species have teliospores with uniformly thick side walls. In the remainder the side wall penetrated by the germ pores is usually conspicuously thicker than the rest of the wall. This unilateral thickening is often accompanied by a tendency to curvature away from the thickened side. This is especially conspicuous in *P. scimitriformis*.

Most of the teliospores have rugose walls but this may be so indistinct as to be of no real value in some species. Most germinate without a rest period. The germ pore is apical or nearly so in the upper cell while that of the lower cell is adjacent to the septum.

The following key is presented as an aid in differentiating the species described here:

[1] Cooperative investigations between the Purdue University Agricultural Experiment Station and the Division of Mycology and Disease Survey, Bureau of Plant Industry, Soils, and Agricultural Engineering, United States Department of Agriculture. Journal Paper Number 344, of the Purdue University Agricultural Experiment Station. Contribution from the Department of Botany and Plant Pathology.

[2] The rusts reported in this paper were collected in cooperation between the Farlow Herbarium of Harvard University and the University of Nanking. They were made available for study through the courtesy of the late Dr. D. H. Linder. All specimens are deposited in the Arthur Herbarium, Purdue University and the Farlow Herbarium, Harvard University. Unless otherwise stated collections are by S. Y. Cheo.

Sori deep-seated, cup-like, next the palisade layer.
Sori 100 μ or less in diameter.
Side walls of teliospores uniformly 1.5–2 μ.
Teliospores ellipsoid, 15–20 × 39–56 (–60) μ. *P. cinnamomicola.*
Teliospores cylindric, 10–19 × 65–96 μ. *P. seposita.*
Side walls of teliospores unilaterally thickened.
Teliospores broad, 14–20 × 50–75 μ, nearly straight. *P. morata.*
Teliospores narrow, 12–15 × 60–83 (–90) μ, curved. *P. scimitriformis.*
Sori 100–175 μ in diameter.
Side walls of teliospores uniformly 1.5–2 μ.
Teliospores oblong-ellipsoid, 14–19 × 47–60 μ. *P. cara.*
Teliospores ellipsoid, 17–25 × 45–72 μ. *P. aequitatis.*
Side walls of teliospores unilaterally thickened; teliospores 17–22 × (53–) 57–86 (–92) μ. *P. machili.*
Sori not deep-seated, subepidermal, 200 μ or more in diam., side walls of teliospores uniform.
Teliospore wall obviously rugose-reticulate, spores 16–23 × (48–) 52–75 μ. *P. machilicola.*
Teliospore wall obviously verruculose, spores 22–26 (–29) × 43–55 (–60) μ. *P. coronopsora.*
Teliospore wall smooth, spores 13–17 (–19) × (52–) 65–96 (–105) μ. *P. lauricola.*

Puccinia cinnamomicola Cummins, sp. nov. (fig. 1). Spermagoniis non visis. Aeciis sterilibus teliis consociatis usque ad 90 μ diam., ex cellulis peridioideis compositis; cellulis individuis 12–15 × 14–20 μ, membrana 2.5–3.5 μ crassa, verrucosa. Urediis nullis. Teliis hypophyllis, in maculis brunneis leniter incrassatis circinater aggregatis, obscure brunneis, pulvinatis, profunde immersis, 80–100 μ diam.; teliosporis (fig. 1) ellipsoideis, utrinque rotundatis vel deorsum plus minusve attenuatis, medio constrictis, 15–20 × 39–56 (–60) μ; membrana 2 μ crassa vel ad apicem usque ad 3.5 μ, aureo- vel cinnamomeo-brunnea, minuteque rugosa vel apparenter levi, poris germ. in cellulis superioribus apicalibus, inferioribus ad septum dispositis; pedicello hyalino, tenui, 3 μ crasso, usque ad 200 μ longo, tenuiter tunicato, fragili. Statim germ.

On *Cinnamomum* sp. KWANGSI PROV: Ta Tseh Shan, YUNG HSIEN, Aug. 22, 1933, *Cheo 2557* (TYPE).

Because of the presence of sterile aecia composed of compacted cells, which apparently are non-functional, this rust could doubtless be placed in the genus *Xenostele*. In *X. litseae* (Pat.) Syd. and *X. echinacea* (Berk.) Syd., however, the teliospores develop in the base of the aecial peridium. This is not true of Cheo's collection, the telia forming separate, deep-seated sori associated with the aecia. Teng (Sinensia **11**: 110. 1940) reports similar development for *Xenostele neolitseae* Teng. The peculiar structure of the aecia provides the only distinguishing feature since the teliospores are typically puccinioid. The discovery of species in which the telia do not form within the peridium casts doubt upon the validity of the genus. In the series of obviously closely related species reported here, *P. cinnamomicola* is the only one in which aecia occur; there is no character to indicate clearly that the others should be assigned to *Xenostele*.

X. neolitseae is similar to *P. cinnamomicola* but both aecia and telia are considerably wider, as are the teliospores. Tai (Farlowia **3**: 135. 1947) has recently described *Puccinia cinnamomi*, on *Cinnamomum* sp. from Szechuan. Aecia are not reported and the teliospores are longer, the lower limit (60 μ) corresponding to the upper limit for *P. cinnamomicola*.

While the sorus in the leaf tissue is small the exposed spore pustules may reach a diameter of 1 mm. and frequently coalesce in a single ring 2–3 mm. in diameter.

Puccinia seposita Cummins, sp. nov. (fig. 2). Pycniis, aeciis, et urediis ignotis. Teliis hypophyllis, sparsis, brunneis, pulvinatis, masculis brunneis epiphyllis insidentibus, profunde immersis, 75–100 μ diam.; teliosporis (fig. 2) cylindraceis, utrinque attenuatis, medio non vel vix constrictis, 10–19 × 65–96 μ; membrana aureo- vel cinnamomeo-brunnea, 1.5–2 μ crassa vel ad apicem 3–5 μ, minuteque rugosa sed apparenter levi, poris germ. in cellulis superioribus apicalibus, in cellulis inferioribus juxta septum dispositis, pedicello tenui, hyalino vel flavido, 3–4 μ crasso, 150–250 μ longo, tenuiter tunicato. Statim germ.

On *Benzoin* sp. KWANGSI PROV.: Ling Wang Shan, SAN KIANG HSIEN, Sept. 19, 1933, *Cheo 2817* (TYPE).

As in other species of this series the exposed spore mass may reach a diameter of 1 mm. The species is clearly distinct from others having deep-seated sori because of the long, narrow spores with uniform side walls. In these characters it is more like *P. lauricola* which, however, has subepidermal, broad sori and smooth spores.

Puccinia morata Cummins, sp. nov. (fig. 3). Spermagoniis, aeciis, et urediis ignotis. Teliis hypophyllis, sparsis, pulvinatis, castaneo-brunneis, maculis nullis, profunde immersis, 65–80 μ diam.; teliosporae (fig. 3) cylindraceae, utrinque plus minusve attenuatae, medio non vel vix constrictae, 14–20 × 50–75 μ; membrana aureo- vel cinnamomeo-brunnea, minuteque rugosa vel apparenter levi, unilateraliter incrassata, partim tenui 1.5 μ, partim incrassati 3–5 μ, ad apicem 6–9 μ crassa, poris germ. in cellulis superioribus plus minusve subapicalibus, inferioribus juxta septum dispositis; pedicello hyalino, tenui, 3–4 μ crasso, 100–200 μ longo, tenuiter tunicato, semipersistenti. Verisimiliter statim germ.

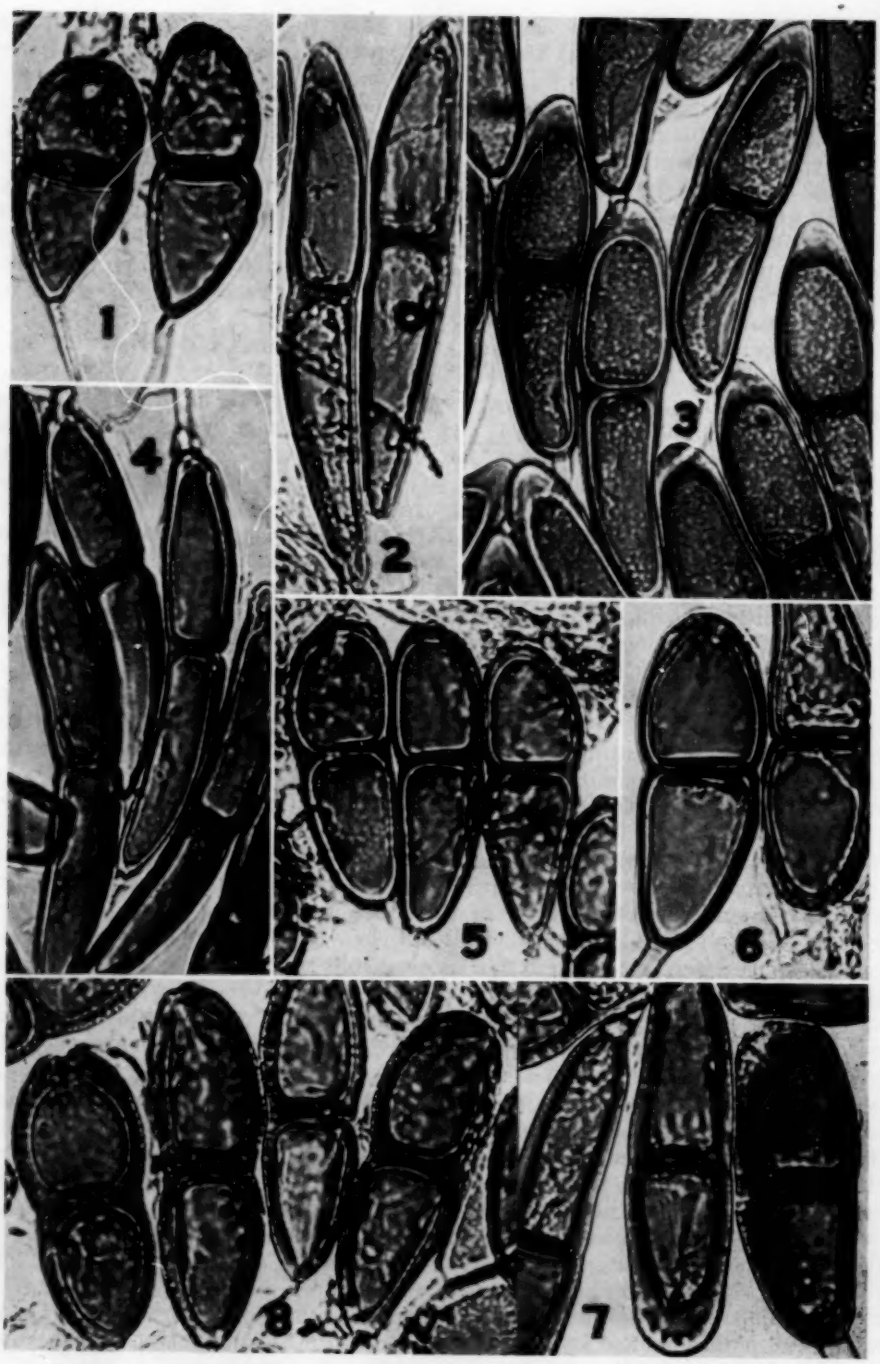
On *Litsea* sp. KWANGSI PROV.: Lao Shan, LING YUIN HSIEN, Apr. 25, 1933, *Cheo 1950* (TYPE).

This is one of three species exhibiting marked unilateral thickening, the pore-bearing wall always thicker. The apical pore, in these species usually is slightly subapical. Curvature of the spore is much less pronounced than in *P. scimitriformis* which, in addition, has narrower spores. No germinated spores were observed but it is probable that an extended period of rest is not requisite to germination.

Puccinia scimitriformis Cummins, sp. nov. (fig. 4). Spermagoniis, aeciis, et urediis ignotis. Teliis hypophyllis, sparsis, castaneo-brunneis, pulvinatis, profunde immersis, 60–90 μ diam.; teliosporis (fig. 4) plerumque curvatis, cylindraceis, utrinque attenuatis, medio non vel vix constrictis, 12–15 × 60–83 (–90) μ; membrana aureo- vel cinnamomeo-brunnea, minuteque rugulosa vel levi, unilateraliter incrassata, partim tenui 1.5–2 μ, partim incrassata 2.5–4 μ; poris germ. in cellulis superioribus apicalibus, inferioribus juxta septum dispositis; pedicello tenui, hyalino vel flavido, 3–4 μ crasso, usque ad 150 μ longo, tenuiter tunicato, fragili. Statim germ.

On *Persea* sp. KWANGSI PROV.: Ta Tseh Shan, YUNG HSIEN, Aug. 23, 1933, *Cheo 2568* (TYPE).

In this species the unilateral thickening of the side wall is usually pronounced, as is also the associated curvature of the spore. Here the curva-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ture is so conspicuous that the spores are scimiter-shaped. The exposed pulvinate spore mass may reach a diameter of 1 mm.

Puccinia cara Cummins, sp. nov. (fig. 5). Spermagonia, aecia, et uredia ignota. Telia hypophylla, sparsa, pulvinata, brunnea, maculis indistinctis vel fere nullis insidentia, profunde immersa, 110–140 μ diam.; teliosporis (fig. 5) oblongo-ellipsoideis, utrinque rotundatis vel deorsum attenuatis, medio non vel vix constrictis, 14–19 × 47–60 μ; membrana pallide castaneo-brunnea, minuteque rugulosa, 1.5–2 μ crassa, ad apicem 3–5 (–7) μ crassa; poris germ. in cellulis superioribus apicalibus, in inferioribus juxta septum dispositis; pedicello hyalino, tenui, 3–4 μ crasso, 100–200 μ longo, tenuiter tunicato, fragili. Statim germ.

On *Benzoin* sp. KWANGSI PROV.: Ta Tseh Shan, YUNG HSIEN, Aug. 29, 1933, *Cheo 2640* (TYPE).

The teliospores of *P. cara* are generally similar in shape to those of *P. machilicola* but average both narrower and shorter. The walls of *P. cara* are thinner and, as shown in the key, the sori are deep-seated and cup-shaped rather than broad and subepidermal.

Occasionally a few abortive spores or pharaphysis-like structures occur in the sori.

Puccinia aequitatis Cummins, sp. nov. (fig. 6). Spermagonia, aecia, et uredia ignota. Teliis hypophyllis in greges 3–6 dispositis, pulvinatis, brunneis, profunde immersis, 125–175 μ diam.; teliosporis (fig. 6) plerumque ellipsoideis, ad apicem rotundatis, deorsum attenuatis, medio leniter constrictis, 17–25 × 45–72 μ; membrana aureo- vel pallide castaneo-brunnea, minuteque rugulosa vel apparenter levi, 2 μ crassa vel ad apicem 3–4 μ; poris germ. in cellulis superioribus apicalibus, inferioribus juxta septum dispositis. Pedicello hyalino, tenui, 3–4 μ crasso, 100–120 μ longo, tenuiter tunicato, semipersistenti. Statim germ.

On *Benzoin* sp. KWANGSI PROV.: Loh Hoh Tsuen, LING YUIN HSIEN, Apr. 30, 1933, *Cheo 1995* (TYPE).

P. aequitatis is quite similar to *P. cara* but with somewhat larger, especially broader, spores. The wall is more finely rugose than in *P. cara*, with the lower one-half or two-thirds apparently smooth.

Explanation of figures 1–8

FIG. 1. Teliospores of *Puccinia cinnamomicola*. From type, *Cheo 2557*. FIG. 2. Teliospores of *Puccinia seposita*. From type, *Cheo 2817*. FIG. 3. Teliospores of *Puccinia morata;* note the unilateral thickening of the walls on the side penetrated by the germ pore and the tendency toward curvature of the spore. From type *Cheo 1950*. FIG. 4. Teliospores of *Puccinia scimitriformis;* curvature of the spore and associated unilaterally thickened side walls are pronounced. From type, *Cheo 2568*. FIG. 5. Teliospores of *Puccinia cara*. The wall in this species is obviously, but minutely rugose. From type, *Cheo 2640*. FIG. 6. Teliospores of *Puccinia aequitatis;* generally similar to *P. cara* but with broader spores becoming smooth on the lower half. From type, *Cheo 1995*. FIG. 7. Teliospores of *Puccinia machili;* this is one of the thick-walled, minutely rugose species showing unilateral wall thickening but without accompanying curvature. The pores obviously penetrate the thick side wall. From type, *Cheo 1976*. Species illustrated in figures 1–7 have deep-seated, cup-shaped telia. FIG. 8. Teliospores of *Puccinia machilicola;* note the obviously roughened wall, the marking consisting of reticulately anastomosing ridges. The sori in this species are broad and merely subepidermal. From type, *Cheo 330*. All figures × 800.

Puccinia machili Cummins, sp. nov. (fig 7). Spermagoniis, aeciis, et urediis ignotis. Teliis hypophyllis, circinate dispositis vel dense aggregatis, pulvinatis, castaneo-brunneis, maculis brunneis indistinctis vel fere nullis, profunde immersis, 100–175 μ diam.; teliosporis (fig. 7) longe ellipsoideis vel cylindraceis, ad apicem plus minusve rotundatis, deorsum plerumque attenuatis, medio non vel vix constrictis, 17–22 × (53–) 57–86 (–92) μ; membrana obscure aureo-brunnea vel pallide castaneo-brunnea, minuteque rugosa, unilateraliter incrassata, in parti tenui 1.5–3 μ crassa, partim incrassato 3.5–6 μ crassa, ad apicem 6–9 μ crassa, poris germ. in cellulis superioribus plus minusve subapicalibus, in inferioribus juxta septum dispositis; pedicello hyalino vel flavidulo, tenui, 3–5 μ crasso, usque ad 200 μ longo, tenuiter tunicato, plus minusve persistenti. Statim germ.

On *Machilus* sp. KWANGSI PROV.: Lao Shan, LING YUIN HSIEN, Apr. 29, 1933, *Cheo 1976* (TYPE); Apr. 22, 1933, *Cheo, 1920.*

The two collections do not agree in all respects. In the type the sori are confluent in a single circle up to 2 mm. in diameter, the thin side wall of the spore is usually 3 μ in thickness, and the spores average slightly broader and shorter than those of No. 1920. The sori in No. 1920 are more tightly grouped, thus not conspicuously circinate, and the thin side walls of the spores are only 1.5–2 μ.

The side of the spore on which the pores are located is usually strongly thickened but without the pronounced curvature of the spore that is characteristic of *P. scimitriformis.*

Puccinia machilicola Cummins, sp. nov. (fig. 8). Spermagoniis, aeciis, et urediis ignotis. Teliis hypophyllis, brunneis, pulvinatis, sparsis vel in greges usque ad 2 mm. diam. dense aggregatis, subepidermalibus, 160–200 μ diam.; teliosporis (fig. 8) oblongo-ellipsoideis vel ellipsoideis vel cylindraceis, medio non vel leniter constrictis, utrinque rotundatis vel deorsum attenuatis, 16–23 × (48–)52–75 μ; membrana pallide castaneo-brunnea vel obscure aureo-brunnea, rugoso-reticulata, 2–3 μ crassa vel ad apicem usque ad 5 μ crassa, poris germ. in cellulis superioribus apicalibus, inferioribus juxta septum dispositis; pedicello hyalino, tenui, 3 μ crasso, 100–200 μ longo, tenuiter tunicato, fragili. Statim germ.

On *Machilus* sp. KWEICHOW PROV.: SZE NAN HSIEN, Aug. 27, 1931, *Cheo 330* (TYPE).

This is one of the few species in which the sculpturing of the wall is distinct, although fine. The pattern consists of labyrinthiform ridges, frequently so regularly united as to result in obvious reticulation.

Puccinia coronopsora Cummins, sp. nov. (fig. 12). Spermagonia, aecia, et uredia ignota. Telia hypophylla in greges usque ad 3 mm. diam. disposita, pulvinata, castaneo-brunnea, subepidermalia, 150–300 μ diam.; teliosporis ellipsoideis, utrinque rotundatis vel deorsum leniter contractis, medio non vel vix constrictis, 22–26(–29) × 43–55 (–60) μ; membrana castaneo-brunnea, minuteque verruculosa, 3–4 μ crassa, ad apicem 5–7 μ crassa; poris germ. in cellulis superioribus apicalibus inferioribus juxta septum dispositis; pedicello hyalino, 5–6 μ crasso, 75–150 μ longo, persistenti, prope hilum crasse tunicato, deorsum plus minusve ruguloso.

On *Lindera* sp. KWEICHOW PROV.: Lao Ling, CHIANG K'OU HSIEN, Nov. 16, 1931, *Cheo 868* (TYPE).

P. coronopsora is one of the more distinctive species of the series on

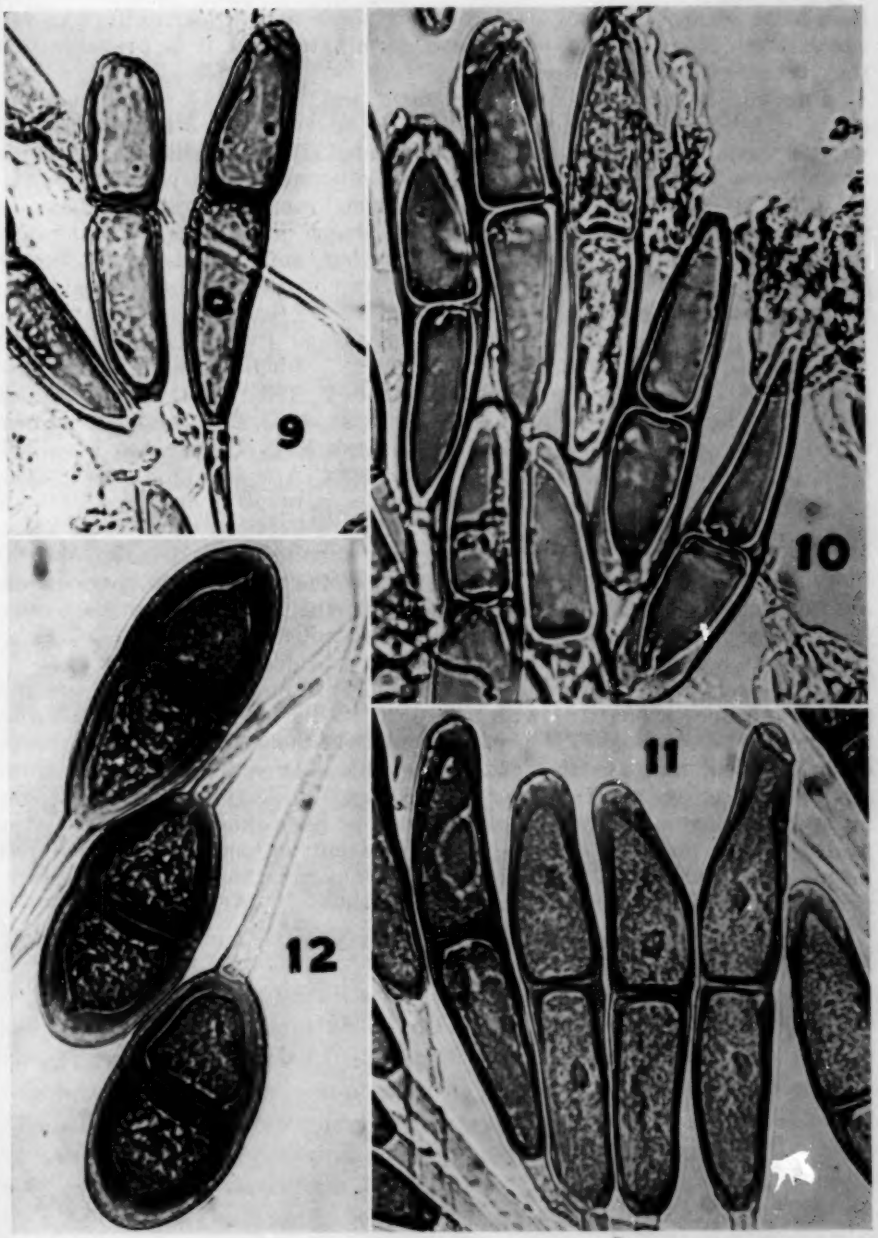

FIG. 9. Teliospores of *Puccinia lauricola;* collections with spores corresponding to these are doubtfully placed in this species. From *Cheo 409.* FIG. 10. Teliospores of *Puccinia lauricola.* From *Cheo 1890.* FIG. 11. Teliospores of *Puccinia lauricola.* This species is typically smooth-spored. From type, *Cheo 1724.* FIG. 12. Teliospores of *Puccinia coronopsora.* From type, *Cheo 868.* Species illustrated in figures 9–12 have broad, subepidermal telia. All figures × 800.

Lauraceae because of the dark, ellipsoid spores with thick, uniformly verrucose wall. None of the spores have germinated and it is probable that they require a period of dormancy.

Puccinia lauricola Cummins, sp. nov. (figs. 9, 10, 11). Spermagoniis, aeciis, et urediis ignotis. Teliis hypophyllis, sparsis vel 2–3 aggregatis, pulvinatis, castaneo-brunneis, supepidermalibus, 175–250 μ diam.; teliosporis cylindraceis, utrinque plus minusve contractis, medio non vel vix constrictis, 13–17 (–19) × (52–) 65–96 (–105) μ; membrana obscure aureo-brunnea vel pallide castaneo-brunnea, levi, 1.5–2 μ crassa, ad apicem 4–12 μ crassa; poris germ. in cellulis superioribus apicalibus, inferioribus juxta septum dispositis; pedicello hyalino, 4–5 μ crasso, usque ad 350 μ longo, persistenti, prope sporum crasse tunicato. Statim germ.

On *Lindera strychnifolia* F. Vill. KWANGSI PROV.: Lao Shan, LING YUIN HSIEN, Mar. 25, 1933, *Cheo 1724* (TYPE). On *Benzoin* sp. KWEICHOW PROV.: Lao Ling, FAN CHING SHAN, Sept. 7, 1931, *Cheo 409;* KIANGSI PROV.: Poh Luh Tung, SIN TSZ HSIEN, Sept. 28, 1932, *Cheo 1076*. On Lauraceae (indet.). KWANGSI PROV., Lao Shan, LING YUIN HSIEN, Apr. 12, 1933, *Cheo 1842;* Loh Hoh Tsuen, LING YUIN HSIEN, Apr. 16, 1933, *Cheo, 1890*.

It is probable that more than one species is involved in the collections listed here. This is especially true of the two collections on *Benzoin* (Nos. 409 and 1076). The spores (fig. 9) appear to be minutely rugose, whereas they are smooth in the other collections, but the sori are old, parasitized, and in poor condition for study. It should further be noted that they come from different provinces. Probably the two collections do not belong as placed, but better material will be necessary to decide this point.

Of the remaining collections No. 1890 has circinately arranged sori and smooth teliospores (fig. 10) with an apical wall seldom exceeding 5–7 μ in thickness, while in Nos. 1724 (fig. 11) and 1842 the sori are in tight groups and the apical wall usually 7–12 μ. The wall is smooth in both. All three of these collections are from the same region. While the teliospores in the latter two collections have not germinated, as have those of No. 1890, it is probable that they are capable of germination without an extended rest period. The pedicels in these three collections are thick-walled, relatively persistent, and appear somewhat gelatinized.

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THE SOUTH AMERICAN SPECIES OF ARRACACIA (UMBELLIFERAE) AND SOME RELATED GENERA

LINCOLN CONSTANCE

In our revisionary study of North American Umbelliferae (1944–45), Dr. Mildred E. Mathias and I regarded *Arracacia* Bancroft, with twenty-four species, as the fourth largest genus of the family in the continent, exceeded only by *Lomatium* Raf., with seventy-eight species, *Eryngium* L., with sixty-four, and *Cymopterus* Raf., with thirty-two. The combined ranges of the species of *Arracacia* extend pretty well over the mountainous regions of Mexico and Guatemala, and one reaches Costa Rica and Panama.

For several years, Mr. Elisworth P. Killip, Curator of the Department of Botany of the United States National Museum, has been urging a study of the South American representatives of this group. In addition to the two properly referred classical species, *Arracacia xanthorrhiza* Bancroft (*A. esculenta* DC.) and *A. moschata* (H.B.K.) DC., in the year 1908 Britton described *A. andina* from Boliva and Wolff described *A. elata, A. incisa,* and *Velaea peruviana* from Weberbauer's Peruvian collections. Finally, Rose attached no less than eight different unpublished names to various herbarium collections. Two of Wolff's species were delineated in the absence of mature fruit, and there has been a good deal of confusion in applying his binomials.

Despite the lapse of forty years since Wolff's and Britton's concern with the genus, the material at hand is still much too meagre to permit anything better than a strictly "pioneer" classification. Many of the collections are immature or lack significant structures; others are not readily referable to any described entity but are scarcely adequate for the typification of a new one, although Wolff would almost certainly have differed with me in this view. I should be surprised if the acquisition of additional material did not necessitate a thorough reappraisal of the admittedly tentative scheme offered below. I think we must recognize, however, the necessity of different "levels" of taxonomic work, and be prepared to construct the best treatment possible with the information at hand. The person interested in floristic considerations will not be helped if the "specialist" refuses to prepare a classification of any group until he has sufficient data at his disposal to make, let us say, statistical analyses and cytogenetical investigations, much as he might wish to employ these tools. The appearance of a provisional treatment should afford a working basis for the taxonomist in need of usable

keys and suitable names for his plants, and at the same time call attention to the utility of further collecting by those in a position to do it.

With considerable misgivings, then, but no apology, the following provisional key is offered to the species of *Arracacia* in South America, with supplementary notes on certain genera which have been in one way or another confused with them.

I am greatly indebted to those in charge of the following herbaria for the opportunity of seeing pertinent specimens: Chicago Natural History Museum (F); Gray Herbarium, Harvard University (GH); Missouri Botanical Garden (MO); New York Botanical Garden (NY); University of California (UC); United States National Museum (US).

ARRACACIA Bancroft, Trans. Agr. Hort. Soc. Jamaica **1825**: 3. 1825.
Arracacha DC. Bibl. Univ. Sci. & Arts **40**: 78. 1829.
Velaea DC. Coll. Mém. **5**: 61. 1829.
Vellea D. Dietr.; Steud. Nom. Bot. ed. 2. **2**: 746. 1841.

Stout or slender, erect, herbaceous or somewhat woody, caulescent, branching or simple, glabrous to pubescent perennials, from taproots or tubers. Leaves petiolate, once to several times ternate, pinnate, or ternate-pinnate, the leaflets or ultimate divisions various. Petioles sheathing. Inflorescence of loose to somewhat compact compound umbels; peduncles terminal and lateral, or rarely only terminal, occasionally some umbels sessile. Involucre wanting or vestigial. Involucel of few short to long, narrow bractlets, shorter to longer than the fruit or wanting. Fertile rays few to numerous, spreading-ascending to divaricate and reflexed. Flowers white, greenish-yellow, greenish, reddish-brown or maroon, or purple; petals oblanceolate to obovate with a narrower inflexed apex; calyx teeth obsolete; styles short to long, erect to spreading or reflexed, the stylopodium conic and conspicuous to depressed and indistinct. Carpophore 2-cleft to the base or only bifid at the apex, flat or terete. Fruit lanceolate or oblong to ovoid, usually narrowed at the apex, flattened laterally, glabrous or pubescent; ribs prominent, acute to obtuse, or filiform and indistinct; oil tubes solitary to several in the intervals, 2–several on the commissure; seed subterete in cross section, often channeled under the tubes, the face sulcate or concave.

Type species: *Arracacia xanthorrhiza* Bancroft.

Artificial Key to the Species

Leaves 1–2-ternate or -pinnate or -ternate-pinnate; leaflets lanceolate to ovate with serrate or dentate and usually incised or lobed margins, and without a prominent callus point; involucel evident; rays and pedicels unwebbed.
  Leaflets spinulose-serrate; stylopodium conic; carpophore bifid about ¼ its length; fruit tapering at apex.
    Foliage essentially glabrous; flowers greenish-yellow to white; pedicels 4–6 mm. long.
      Mericarp ribs obtuse; oil tubes all about the same size.
        Fertile rays 4–8; pedicels 4–6 mm. long; mericarp ribs very thick and corky, the intervals broad and shallow; oil tubes large, solitary in the intervals. 1. *A. Pennellii.*

Fertile rays 6–15; pedicels 5–8 mm. long; mericarp ribs thin, the intervals sharply V-shaped; oil tubes very small and indistinct, forming a continous layer between seed and pericarp. 2. *A. elata.*

Mericarp ribs acute; oil tubes of two sizes. 3. *A. Wigginsii.*

Foliage squamulose; flowers usually maroon; pedicels 10–30 mm. long. 4. *A. moschata.*

Leaflets variously serrate to incised or lobed, but not spinulose-serrate; stylopodium depressed; carpophore 2-cleft to the base (unknown in *A. peruviana*); fruit blunt at apex.

Rays 4–8 cm. long; bractlets linear, herbaceous, exceeding the reddish-brown flowers. 5. *A. peruviana.*

Rays 1–4 cm. long; bractlets broad and scarious, or linear and shorter than the purple or greenish flowers.

Bractlets scarious or scarious-margined, lanceolate to obovate.

Bractlets 4–8, obovate to lanceolate, scarious, 5–10 mm. long, exceeding the flowers; mericarp ribs very prominent and corky; oil tubes small, 2–3 in the intervals. 6. *A. incisa.*

Bractlets 3–6, ovate-acuminate, narrowly scarious-margined, 2–6 mm. long, shorter than the flowers; mericarp ribs filiform; oil tubes large, solitary in the intervals. 7. *A. equatorialis.*

Bractlets herbaceous, linear.

Plants 5–12 dm. high; fruit (immature) oblong, 10 mm. long, 2–3 mm. broad, constricted below apex; oil tubes solitary in the intervals. 8. *A. xanthorrhiza.*

Plants 3–4 dm. high; fruit ovoid, 6–7 mm. long, 4–5 mm. broad, not constricted; oil tubes 2–3 in the intervals. 9. *A. andina.*

Leaves ternately decompound, the divisions oblong-linear to filiform with entire margins (in our material) and a prominent callus point; involucel wanting (or vestigial); rays and pedicels webbed. 10. *A. tolucensis* var. *multifida.*

1. **Arracacia Pennellii** Constance, sp. nov.

Herba crassa suffrutescens caulescens glaucescens glabra, 6–36 dm. alta; folia in ambitu ovato-triangularia, 0.8–2 dm. longa, ternata deinde 1–2-pinnata, foliolis ovato-lanceolatis ovatisve, ad apicem acutis vel acuminatis, ad basin cuneatis rotundatisve, 2–5 cm. longis, 1–2 cm. latis, spinuloso-serratis ad basin lobatis; petioli 1.5–2 dm. longi, ad basin vaginates; folia caulina foliis basilaribus similia, vaginis inflatis; inflorescentia ramosa, pedunculis alternis vel terminalibus, 6–25 cm. longis; involucelli bracteolae 5–9, lineari-lanceolatae, inaequales, 2–10 mm. longae; radii fertiles 4–8 graciles patenti-adscendentes 3–7 cm. longi; pedicelli fertiles 2–6, 4–5 mm. longi; flores flavido-virides albive, petalis obovatis; stylopodium conicum, stylis gracilibus; carpophorum bifidum, rigidum; fructus ovoideus, 5 mm. longus, 3–4 mm. latus, costis prominentibus obtusis suberosis, pericarpo suberoso, valleculis latibus brevibusque; vittae magnae solitariae in valleculis, 4 in commissuris; semina sub valleculis canaliculata facie sulcata.

Coarse, suffrutescent, branching, caulescent, glaucous herb, 6–36 dm. high, the foliage essentially glabrous; leaves triangular-ovate, 0.8–2 dm. long, ternate-1–2-pinnate, the leaflets ovate-lanceolate to ovate, acute or acuminate, cuneate to rounded at base, the lower distinct and short-petiolulate, the upper sessile and confluent, 2–5 cm. long, 1–2 cm. broad, spinulose-serrate and usually lobed toward the base, the lower surface paler, glabrous, and reticulate, a squamulose tuft on the upper side of the sulcate rachis at the base of the larger leaflets; petioles 1.5–2 dm. long, narrowly sheathing

at base; cauline leaves mostly with wholly sheathing and inflated petioles; inflorescence branching, the peduncles arising terminally and axially 6–25 cm. long, squamulose at apex; involucre of 1–4 sheath-like membranaceous bracts, or wanting; involucel of 5–9 unequal, linear-lanceolate, entire or trifid bractlets 2–10 mm. long, the longer about equaling the flowers but shorter than the fruit; fertile rays 4–8, slender, spreading-ascending, 3–7 cm. long, scaberulous at apex; fertile pedicels 2–6, spreading, 4–5 mm. long, scaberulous; flowers greenish-yellow to white, the petals obovate; stylopodium conic, the styles slender, erect to reflexed; carpophore bifid about ¼, rigid; fruit ovoid, 5 mm. long, 3–4 mm. broad, tapering at apex, glabrous, the ribs very prominent and corky, obtuse, forming a corky covering over the entire pericarp; oil tubes large, solitary in the very shallow intervals, 4 on the commissure; seed deeply channeled under the intervals, the face sulcate.

TYPE: Moist rocky cañon, alt. 2700–2800 m., Rio San Francisco, above Bogotá, Dept. Cundinamarca, Colombia, 13 September 1917, *F. W. Pennell 1932* (NY: type).

Specimens examined: COLOMBIA. CUNDINAMARCA: Rio San Francisco, above Bogotá, 13–IX–17, *Pennell 1932* (NY-type, GH, US); Macizo de Bogotá, Quebrada del Rosal, 3000 m., 29–VI–39, *Cuatrecasas 5700* (US). NORTE DE SANTANDER: Between Mutiscus and Pamplona, 3400 m., 23–II–27, *Killip & Smith 19,728* (GH, NY, US). SANTANDER: Cordillera Oriental, páramo de Santurbán, entre Cuesta Boba y el extremo oeste, 3400 m., 27–VII–40, *Cuatrecasas & Barriga 10,314* (US); Páramo de Romeral, 3800–4100 m., 29,30–I–27, *Killip & Smith 18,541* (GH, NY, US); vicinity of Vetas, thickets along streams, 3100–3200 m., 16–VI–27, *Killip & Smith 17,347* (GH, MO, NY, US); Quebrada de Pais, north of La Baja, dense forest, ca. 3200 m., 31–I–27, *Killip & Smith 18,781* (GH, MO, NY, US).

This species is very similar in general aspect to the next, but its fewer rays, predominantly shorter pedicels, and strikingly dissimilar fruit section, set it well apart. With no collections available to connect the widely separate ranges of the two entities, it seems advisable to regard them as distinct species.

2. ARRACACIA ELATA Wolff, Bot. Jahrb. **40**: 304. 1908.

Stout, clambering, caulescent, branching, up to 4.5 m. high, the foliage essentially glabrous; leaves ovate, 1–3 dm. long, ternate-1–2-pinnate, the leaflets lanceolate to ovate, acute or acuminate, cuneate to rounded at the base, the lower distinct and short-petiolulate, the upper sessile and confluent, 3–6 cm. long, 1–4 cm. broad, sharply spinulose-serrate and often incised toward the base, the lower surface paler and glabrous, strongly reticulate, a squamulose tuft on the upper side of the sulcate rachis at the base of the larger leaflets; petioles 15–45 cm. long, their lower ⅓ broadly sheathing; cauline leaves similar, the uppermost with petioles wholly sheathing and inflated; inflorescence branching, the peduncles arising axially, 10–25 cm. long, squamulose at apex; involucre wanting, or occasionally of a single leaf sheath; involucel of 8–10 linear to lanceolate, entire or few-toothed unequal bractlets 3–15 mm. long, the longer exceeding the flowers but shorter than the fruit; fertile rays 6–15, slender, spreading-ascending, 3–6 cm. long; scaberulous at apex; fertile pedicels 3–8, spreading, 5–8 mm. long; flowers greenish, the petals oval; stylopodium conic, the styles slender, recurved; carpophore bifid about ¼ its length, rigid; fruit ovoid, 5 mm. long, 3 mm.

broad, glabrous, the ribs prominent, obtuse, with narrow sharply V-shaped intervals; oil tubes very small and indistinct, forming a continuous layer between seed and pericarp; seed deeply channeled under the intervals, the face sulcate.

TYPE: "Peru: Dep. Amazonas, a Chachapoyos orientem versus; inter Tambo Ventillas et Piscohuañuma, in graminosis, in 3300 m. altitudinis," *Weberbauer 4423*.

Specimens examined: PERU. AMAZONAS: "a Chachapoyos orientem versus; inter Tambo Ventillas et Piscohuañuma," 3000 m., VII–04, *Weberbauer 4423* (type photos: F, GH, UC, US). HUANUCO: Tambo de Vaca, ca. 12,000 feet, 10,24–VI–23, *Macbride 4456* (F, US). AYACUCHO: Choimacota Valley, 3000 m., 28–II, 10–III–26, *Weberbauer 7584* (F, GH, US).

The last collection cited has good, mature fruit, permitting the emendation of Wolff's description, which was based upon immature ones. The close resemblance of this species to the foregoing has been mentioned above.

3. **Arracacia Wigginsii** Constance, sp. nov.

Herba crassa suffrutescens caulescens glabra, 2–3 m. alta; folia basalia incognita; folia caulina maiora in ambitu ovato-triangularia, 1–1.5 dm. longa, ternata deinde 1–2-pinnata, foliolis lanceolatis ovato-lanceolatisve, ad apicem acuminatis, ad basin cuneatis rotundatisve, 3–5 cm. longis, 0.8–2 cm. latis, spinuloso-serratis ad basin lobatis; petioli 1–2 dm. longi, ad basin anguste vaginantes; folia caulina superiora similia, petiolo ad laminam vaginato; inflorescentia ramosa, pedunculis terminalibus axillaribusque, 10–16 cm. longis, apice squamuloso; involucelli bracteolae 3–6, lineares oblanceolataeve inaequales, 2–10 cm. longae; radii fertiles 10–15 graciles patenti-adscendentes 3.5–7 cm. longi; pedicelli fertiles 3–8, 4–6 mm. longi; flores flavido-virides albive, petalis obovatis; stylopodium conicum, stylis gracilibus; carpophorum bifidum, rigidum; fructus ovoideus oblongo-ovoideusve, 4–8 mm. longus, 3–3.5 mm. latus, costis acutis prominentibus; vittae vel minimae obscuraeque stratum continuum inter pericarpium et semen formantes vel magnitudine intermediae plerumque solitariae in valleculis omnibus vel aliquis, 2–4 in commissuris; semina sub valleculis canaliculata facie sulcata.

Coarse, suffrutescent, branching, caulescent, 2–3 m. high, the foliage essentially glabrous; basal leaves unknown, the larger cauline leaves triangular-ovate, 1–1.5 dm. long, ternate-1–2-pinnate, the leaflets lanceolate to ovate-lanceolate, acute or acuminate, cuneate to rounded at base, the lower distinct and short-petiolulate, the upper sessile and confluent, 3–5 cm. long, 0.8.2 cm. broad, spinulose-serrate and often lobed toward the base, the lower surface paler, glabrous, and reticulate, a squamulose tuft on the upper side of the sulcate rachis at the base of the larger leaflets; petioles 1–2 dm. long, narrowly sheathing below; petioles of the upper cauline leaves wholly sheathing and inflated; inflorescence branching, the peduncles arising terminally and axially, 10–16 cm. long, squamulose at apex; involucre wanting, or of reduced leaf sheaths; involucel of 3–6 unequal, linear to oblanceolate, entire or trifid bractlets 2–10 mm. long, the longer about equaling the flowers but shorter than the fruit; fertile rays 10–15, slender, spreading-ascending, 3.5–7 cm. long, scaberulous; fertile pedicels 3–8, spreading, 4–6 mm. long, scaberulous; flowers "greenish yellow to nearly white," the petals obovate; stylopodium conic, the styles slender, erect to reflexed; carpophore

bifid about ¼ its length, rigid; fruit ovoid to oblong-ovoid, 4–8 mm. long, 3–3.5 mm. broad, the ribs prominent, acute; oil tubes of two sizes: (1) very small and indistinct, forming a continous layer between seed and pericarp, and (2) vittae of intermediate size, usually solitary in some or each of the intervals, 2–4 on the commissure; seed channeled under the intervals, the face sulcate.

TYPE: Along Pan-American Highway 40 km. south of Cuenca, 10,900 feet, Azuay Prov., Ecuador, 20 September 1944, *Ira L. Wiggins 10,769* (UC 708,757: type).

Specimens examined: ECUADOR. CAÑAR: Vicinity of Cañar, 15–IX–18, *Rose & Rose 22, 715* (NY, US). AZUAY: 40 km. south of Cuenca, *Wiggins 10,769* (UC—type); "Mt. Pillshum," 12,000 feet, *Jameson 24* (GH).

The fruits of the *Rose & Rose* collection, although less mature than those of the type, are markedly longer in proportion to their width, but no other significant difference in structure has been detected. This species is very similar to the two foregoing in general aspect and it is, again, the fruit which affords the principal basis for its separation. The peculiar dimorphism of the oil tubes suggests a blend of the kinds of vittae found in *A. Pennellii* and *A. elata*, but scarcely permits these Ecuadorean specimens to be merged with either the Colombian or the Peruvian species.

4. ARRACACIA MOSCHATA (H.B.K.) DC. Prodr. **4**: 244. 1830.
Conium moschatum H.B.K. Nov. Gen. & Sp. **5**: 12, *pl. 430*. 1821.

Stout, clambering, caulescent, branching, up to 1.5 m. high, the foliage squamulose; leaves ovate, 1.5–3 dm. long, bipinnate or ternate-pinnate, the leaflets ovate-oblong to ovate, acute, cuneate or rounded at base, the lower distinct and short-petiolulate, the upper sessile and confluent, 2–5 cm. long, 1–3 cm. broad, sharply spinulose-serrate and incised or pinnatifid, squamulose on the larger veins on the upper surface, the lower surface paler, glabrous and reticulate, a squamulose tuft on the upper side of the sulcate rachis at the base of the larger leaflets; petioles 10–20 cm. long, usually broadly sheathing; cauline leaves with petioles wholly sheathing and inflated; inflorescence branching, the peduncles arising axially, 1.5–3 dm. long, squamulose at apex; involucre of reduced leaf sheaths or wanting; involucel of 3–8 linear to lanceolate, entire or few-toothed bractlets 6–15 mm. long, the longer exceeding the flowers but shorter than the fruit; rays 8–12, stout, spreading-ascending or spreading, 7–13 cm. long, densely scaberulous; fertile pedicels 1–12, spreading, 10–30 mm. long, densely scaberulous; flowers maroon (rarely yellow), the petals oval; stylopodium conic, the styles slender, recurved; carpophore bifid about ¼ its length, rigid; fruit lance-ovoid, 6–8 mm. long, 3–3.5 mm. broad, the ribs very prominent, acute; oil tubes large, usually solitary in the intervals, about 4 on the commissure, sometimes small supplementary ones under the ribs or in the intervals; seed channeled under the intervals, the face sulcate.

TYPE: "crescit in frigidis Provinciae de los Patos, prope Teindala, [Prov. Azuay, Ecuador], alt. 1400 hex.," *Humboldt & Bonpland.*

Specimens examined: ECUADOR. CARCHI: Wooded hills about 5 miles south of Tulcán, 2500 m., 10–VIII–23, *Hitchcock 21,005* (GH, NY, US); between Tulcán and Pun, 3500 m., 11–VIII–35, *Mexia 7580* (US). PICHINCHA: "cult. ad radicem Montes Pichincha, sive Andium Quintensium," III–64, *Jameson* (US—petals yellow); "in Andibus Ecuador-

ensibus,'' 1857–59, *Spruce 5794* (NY). TUNGURAHUA: ''Weg von Paso nach Ambato am Rio Ambato, stelle steinige Uberberge, Andem um Ambato, 2850 m., haüfig,'' 6–XI–32, *E. Henrichs 71* (NY).

The long rays and pedicels, the leaf-cutting, and the usually maroon flowers distinguish this species sharply from the preceding. The occurrence of small accessory oil tubes is of interest in the light of the differences in vittae described in the first three species. Jameson's note that this species is ''cultivated'' may indicate that other species than *A. xanthorrhiza* either are or have been so employed, but I have no further evidence of the domestication of *A. moschata*.

5. **Arracacia peruviana** (Wolff) Constance, comb. nov.

Velaea peruviana Wolff, Bot. Jahrb. **40**: 303. 1908.

Slender, caulescent, branching, 6–9 dm. high, squamulose to scaberulous throughout, the stem base clothed with dry sheaths, from a branched taproot; leaves ovate-lanceolate, 2–3 dm. long, bipinnate, the leaflets ovate to lanceolate, acute, cuneate at base, the lower distinct and short-petiolulate, the terminal sessile and confluent, 2–5 cm. long, 1–4 cm. broad, coarsely sinuately lobed and mucronulate-serrate, squamulose on the veins and margins, the lower surface paler and reticulate; petioles 1–3 dm. long, sheathing below; cauline leaves pinnate, the uppermost with short, wholly sheathing petioles; inflorescence of alternate axillary peduncles, 7–15 cm. long, squamulose at apex; involucre wanting, or of a single leaf sheath; involucel of 6–10 entire linear bractlets 5–9 mm. long, exceeding the flowers but shorter than the fruit; fertile rays 5–10, slender, spreading-ascending, 4–8 cm. long, squamulose especially at apex; fertile pedicels 2–6, spreading, 5–6 mm. long, squamulose or scaberulous above; flowers reddish-brown, the petals obovate; stylopodium depressed, the styles slender, spreading-erect; carpophore unknown; fruit ovoid, 4–6 mm. long, 3–4 mm. broad, glabrous, the ribs filiform; oil tubes large, solitary in the intervals, 2 on the commissure; seed face deeply and narrowly sulcate.

TYPE: ''Peru: Dep. Ancachs, prov. Cajatambo infra Ocros, in 3000–3200 m. alt.,'' *Weberbauer 2748*.

Specimens examined: PERU. ANCACHS: ''prov. Cajatambo infra Ocros,'' *Weberbauer 2748* (type photo: F). MOQUEGUA: Carumas, 2900 m., 21–II, 6–III–25, *Weberbauer 7269* (F, US). AYACUCHO: Mountains northeast of Huanta, 3200 m., 1,10–II–26, *Weberbauer 7513* (F).

As shown by Coulter and Rose (1900), the type species of *Velaea* DC. (*Ligusticum tolucensis* H.B.K.) is an *Arracacia*, and hence *Velaea* must be merged under *Arracacia*. None of the specimens available for study bear mature fruit, so the description of that organ has been abstracted from Wolff's original description. This species is not likely to be confused with those that precede it, and it is separable from those that follow by its conspicuous linear bractlets and reddish-brown flowers. The Weberbauer collection from Huanta has atypically short involucels, but it may be semisterile.

6. ARRACACIA INCISA Wolff, Bot. Jahrb. **40**: 305. 1908.

Stout, caulescent, branching, 3–12 dm. high, the foliage squamulose; leaves triangular-ovate to ovate-lanceolate, 1–2.5 dm. long, ternate-pinnate or bipinnate, the leaflets triangular-ovate to ovate-oblong, acute, cuneate or truncate at base, the lower distinct and short-petiolulate, the upper sessile

and the larger pinnately incised, squamulose on the margins and along the veins on both surfaces, the lower surface paler and reticulate, a squamulose tuft on the upper side of the sulcate rachis at the base of the larger leaflets; petioles 8–16 cm. long, narrowly sheathing at the base, the sheaths scaberulous on the veins; cauline leaves with wholly sheathing, inconspicuously inflated petioles; inflorescence branching, the peduncles arising axially and terminally, 2–12 cm. long, squamulose at apex; involucre wanting, or of 1 or 2 sheathing bracts; involucel of 4–8, obovate to lanceolate, scarious, denticulate-margined, unequal bractlets 5–10 mm. long, the green central portion projecting as an acuminate point, exceeding the flowers but shorter than the fruit; fertile rays 4–8, stout, spreading-ascending, 1–4 cm. long, scaberulous at least at apex; fertile pedicels 2–6, stout, spreading, usually 2–5 mm. long, scaberulous; flowers dark purple or greenish, the petals obovate; stylopodium depressed, the styles slender, divaricate; carpophore 2-cleft to the base, lax; fruit ovoid, 5–8 mm. long, 3.5–6 mm. broad, the ribs very prominent and corky, acute; oil tubes small, 2–3 in the intervals, 3–6 on the commissure, some accessory ones frequently under the ribs or in the intervals; seed scarcely channeled under the intervals, the face deeply sulcate.

TYPE: "Peru: in declivibus rupestribus prope Tambo, ad viam ferream inter oppida Lima et Oroya," [Dept. Lima], 2650 m., *Weberbauer 165*.

Specimens examined: PERU. HUÀNUCO: Steep rocky open grassy slope, ca. 6500 feet, Huacachi, estacion near Muña, 20–V,1–VI–23, *Macbride 4163* (F, US); in shrub on southwestern canyon slope, ca. 10,000 feet, Yanahuanca, 16,22–VI–22, *Macbride & Featherstone 1244* (F). LIMA: "in declivibus rupestribus prope Tambo, ad viam ferream inter oppida Lima et Oroya," *Weberbauer 165* (type photos: F, GH, UC); Huarochiri, Viso, sandy hillside, sun, 2800 m., 22–IV–39, *Goodspeed, Stork & Horton 11,540* (GH, UC); Prov. Huarochiri, valley of Rio Rimac near Lima—Oroya highway at km. 90 east of Lima, 3000 m., 15,22–III–42, *Goodspeed & Weberbauer 33,059* (GH, UC, US); in firm soil of steep southern slope, sparsely shrubby, ca. 8000 feet, Matucana, 12–IV,3–V–22, *Macbride & Featherstone 326* (F, US); open slopes, ca. 8000 feet, Matucana, 14,18–III–23), *Macbride 2949* (F, NY, US); rocky slopes, ca. 12,000 feet, Rio Blanco, 8,19–V–22, *Macbride & Featherstone 730* (F, US). CUZCO: Cuzco, 1–IX–14, *Rose & Rose 19,034* (US).

The plants represented by *Macbride 4163* are much larger in stature and fruit than the other collections cited, but these seem to be the only differences. Wolff apparently wrote his original diagnosis from highly unsatisfactory, immature, and possibly sterile material; it is difficult otherwise to reconcile the excellent material now available with his very erroneous depiction of, for example, the involucels and stylopodium. As a consequence, this species and *A. peruviana* have been generally confused by, among others, the writer, although the involucels of the two species are entirely different. The conspicuous scarious involucels setting off the usually deep purple flowers, and the blunt, prominently ribbed fruit make this one of the most distinctive species of the group.

7. **Arracacia equatorialis** Constance, sp. nov.

Herba gracilis ramosa caulescens squamulosa, 4–8 dm. alta; folia in ambitu ovato-triangularia, 6–9 dm. longa, bipinnata, foliolis ovatis, ad apicem acuminatis, ad basin cuneatis truncatisve, 1.5–3 cm. longis, 1–2.5 cm. latis, mucronato-serratis basi lobatis squamulosis; petioli 10–20 cm. longi, ad basin vaginantes; folia caulina similia, foliolis linearibus lanceolatisve elongatis, petiolo ad laminam vaginante; inflorescentia ramosa, pedunculis

verticillatis vel solitariis, ad apicem squamuloso; involucelli bracteolae 3–6, ovato-acuminatae, ad marginem membranaceae, 2–6 mm. longae; radii fertiles 2–6, graciles, patenti-adscendentes, ad apicem scabriusculi, 2–4 cm. longi; flores purpurei, petalis obovatis; stylopodium depressum, stylis gracilibus; carpophorum bipartitum, laxum; fructus ovoideo-oblongus, 8–9 mm. longus, 3–4 mm. latus, costis filiformibus acutis; vittae magnae solitariae in valleculis, 2 in commissuris; semina sub vittis canaliculata facie sulcata.

Slender, erect, caulescent, branching, 4–8 dm. high, the foliage squamulose; leaves triangular-ovate, 6–9 cm. long, biternate or bipinnate, the leaflets ovate, acute or acuminate, cuneate to truncate at base, the lower distinct and short-petiolulate, the upper sessile and confluent, 1.5–3 cm. long, 1–2.5 cm. broad, mucronate-serrate and the larger incised or lobed, squamulose on the sheaths, rachises, veins, and margins beneath with linear scales, squamulose or merely scaberulous above, the lower surface paler and reticulate, a squamulose tuft on the upper side of the sulcate rachis at the base of the larger leaflets; petioles 10–20 cm. long, sheathing only at the base; cauline leaves reduced upwards, with linear to lanceolate, elongate divisions, the obovate petioles wholly sheathing, little inflated; inflorescence branching, the peduncle arising in whorls or singly, 2–12 cm. long, the terminal sometimes subsessile, squamulose at apex; involucre wanting; involucel of 3–6 ovate-acuminate, entire, subequal, narrowly scarious-margined bractlets 2–6 mm. long, shorter than the flowers and fruit; fertile rays 2–6, slender, spreading-ascending, 2–4 cm. long, scaberulous; fertile pedicels 1–3 (–5), stout, ascending, 3–5 mm. long; flowers purple, the petals obovate; stylopodium depressed, the styles slender, spreading-ascending; carpophore 2-cleft to the base, lax, filiform; fruit ovoid-oblong, 8–9 mm. long, 3–4 mm. broad, glabrous, the ribs filiform, acute; oil tubes large, solitary in the intervals, 2 on the commissure; seed channeled under the tubes, the face deeply sulcate.

TYPE: "vicinity of Las Juntas [Prov. Loja], Ecuador," 28 September 1918, *Rose, Pachano & Rose 23,215* (US 1,022,735: type).

Specimens examined: ECUADOR LOJA: Vicinity of Las Juntas, *Rose et al. 23,215* (US—type, GH, NY); entre S. Pedro y Chinchas (unos 55 km. O. Loja), 1600 m., 1–III–47, *E. Espinosa 1305* (UC).

Rose gave to the type collection an herbarium name which is preëmpted in the genus by *A. humilis* Rose, described from Guatemala. The Ecuadorean species is nearest *A. xanthorrhiza* and *A. andina*, differing from the former in its fruit and from the latter in its foliage and oil tubes. The Espinosa collection is immature but probably belongs here.

8. ARRACACIA XANTHORRHIZA Bancroft, Trans. Agr. Hort. Soc. Jamaica **1825**: 5. 1825.

Conium Arracacha Hook. Exot. Fl. *pl. 152.* 1825.

Arracacha esculenta DC. Bibl. Univ. Sci. & Arts **40**: 78. 1829.

Bancroftia xanthorrhiza Billb. Linn. Samf. Handl. **1**: 40. 1833.

Stout, caulescent, branching, 5–12 dm. high, glaucous, the foliage squamulose and scaberulous; leaves broadly ovate, 10–35 cm. long and broad, biternate or bipinnate, the leaflets ovate-lanceolate to triangular-ovate, acuminate, cuneate to rounded at base, the lower distinct and often short-petio-

lulate, the upper sessile and confluent, 4–12 cm. long, 1.5–6.5 cm, broad, coarsely simply or doubly mucronate-serrate and incised or lobed, squamulose or scaberulous on the rachises, veins, and margins with flattened oblong or linear scales, the lower surface pale and reticulate, a squamulose tuft on the upper side of the sulcate rachis at the base of the larger leaflets; petioles 0.8–4.5 dm. long, sheathing only at base; cauline leaves reduced upwards, mostly ternate or 3-parted, with lanceolate, acuminate divisions, the lower alternate and petiolate, the upper often opposite and wholly sheathing with narrow, scarcely inflated sheaths; inflorescence branching, the peduncles arising in whorls or singly, 3–10 cm. long, squamulose or scaberulous at apex; involucre wanting; involucel of 5–8 linear, entire, unequal, herbaceous bractlets 2–5 mm. long, shorter than the flowers and fruit; fertile rays 5–12, slender, spreading-ascending, 1.5–4 cm. long, scaberulous; fertile pedicels 3–8, slender, spreading-ascending, 2–4 mm. long; flowers purple or greenish, the petals oval; stylopodium depressed, the styles slender, ascending; carpophore 2-cleft to the base; immature fruit oblong, 10 mm. long, 2–3 mm. broad, constricted below the apex, glabrous, the ribs prominent, acute; oil tubes rather large, solitary in the intervals, 2 on the commissure; seed channeled under the tubes, the face deeply sulcate.

TYPE: Jamaica, where cultivated from South America, probably Colombia.

Specimens examined: ECUADOR. LOJA: Vicinity of Las Juntas, *Rose et al. 23,215* *Rose & Rose* (US—foliage). COLOMBIA. *?Moritz 1803* (F. NORTE DE SANTANDER: Cordillera Oriental, region del Sarare: Hoya de río Chitagá, á sobre La Cabuya, 1600–1800 m., 13–X–41, *Cuatrecasas, Schultes & Smith 12,146* (F, GH-foliage). ANTIOQUIA: Cordillera Central, alrededores de Medellín, 1560 m., 1–V–46, *W. H. Hodge 6861* (GH). CAUCA: Popayan, *Lehmann B.T.407* (GH—flowers); Cuestá de Tocotá, road from Buenaventura Calí, Western Cordillera, 1500–1900 m., XII–05, *Pittier 714* (US). PUTUMAYO: Valle de Sibundoy, los alrededores, ca, 2250 m., 18–II–42, *R. E. Schultes 3267* (GH—foliage). BOLIVIA. LA PAZ: Sorata, IX–I–58, 2697 m., *Mandon 595* (GH), 22–IV–20, *Holway & Holway 563* (US—foliage); Sirupaya, 1800 m., 27–XII–06, *Buchtien 5971* (US—foliage). ECUADOR. TUNGURAHUA: Ambato, 1918,*G. Rose 38* (GH, US—photo of foliage). PERU. CUZCO: Paruro, Hda. Araypallpa, 3100 m., 28–VII–37, *Vargas 411* (GH); colinas del Laxaihuamán, 3600 m., XII–28, *Herrera 858* (F); Ollantaytambo, ca. 3000 m., 24–IV–15, *Cook & Gilbert 282* (US—foliage); Santa Ana, ca. 900 m., 29–VI–15, *Cook & Gilbert 1583* (US—foliage); San Miguel, Urubamba Valley, ca. 1800 m., 26–V–15, *Cook & Gilbert 934* (US—foliage), *935* (US—foliage).

This, the commonly cultivated *arracacha* of northern South America, is represented in herbaria by only unsatisfactory material, and published descriptions are correspondingly inaccurate. I have not seen mature fruit, and it has never been described, to my knowledge; because the plants are ordinarily propagated vegetatively, fruit may not normally ripen. There appears to be no information available on the cultivation of the species that was not incorporated by Hooker (1831) in his description in the Botanical Magazine. None of the material seen is unquestionably from the wild, and I find in it no clues as to the indigenous occurrence and possible original home of the domesticated plant. Hooker's material came from Bogotá, Colombia, by way of Jamaica. What appear to be the most closely related species, however, are *P. equatorialis* of Ecuador and *P. andina* of Bolivia. It is hoped that the publication of this study may stimulate interest in

discovering more information about this crop plant, its domestication, and its origins.

9. ARRACACIA ANDINA Britton, Bull. Torrey Club **18**: 37. 1908.

Stout, erect, caulescent, branching, 3–4 dm. high, the foliage squamulose; leaves ovate, 1–2.5 dm. long, 1–2-pinnate, the leaflets lanceolate to ovate, usually acuminate and cuneate at base, the lower distinct and short-petiolulate, the upper sessile and confluent, 2–8 cm. long, 1–3 cm. broad, mucronate-serrate and the larger incised or lobed, squamulose on the rachises, veins, and margins with flattened linear scales, the lower surface paler and reticulate, a squamulose tuft on the upper side of the sulcate rachis at the base of the larger leaflets; petioles 15–35 cm. long, sheathing only at base; cauline leaves like the basal, the uppermost with obovate, wholly sheathing, moderately inflated petioles; inflorescence branching, the pecuncles arising in whorls or singly, 5–12 cm. long, squamulose at apex; involucre wanting; involucel of 6–8 linear entire unequal herbaceous bractlets 2–5 mm. long, shorter than the flowers and fruit; fertile rays 5–8, slender, spreading-ascending, 2–4 cm. long, scaberulous; fertile pedicels 3–8, spreading, 2–4 mm. long; flowers purple, the petals obovate; stylopodium depressed, the styles slender, spreading; carpophore 2-cleft to the base, the divisions filiform; fruit ovoid, 6–7 mm. long, 4–5 mm. broad, the ribs filiform, acute; oil tubes of intermediate size, 2–3 in the intervals, 4–6 on the commissure; seed shallowly channeled under the larger tubes, the face deeply sulcate.

TYPE: "Ingenio del Oro [Bolivia]," 10,000 feet, III-86, *Rusby 1776* (NY: type).

Specimens examined: BOLIVIA. "Plantae Bolivianae," *Bang 2839* (F, GH, MO, NY, (US); Ingenio del Ovo, *Rusby 776* (F, NY—TYPE, US).

The broad leaflets, different fruit, and clustered oil tubes separate this species from *A. xanthorrhiza*, and the different involucel and oil tubes distinguish it from *A. equatorialis*, but these appear to be its closest relatives. To either this species or to *A. equatorialis* may belong the three following Peruvian collections which, because of their immaturity or fragmentary nature, I am unable to assign definitely to any species: Huasahuasi, *Ruiz & Pavon* (F); Hacienda Churú, Paucartambo Valley, I-27, *Herrera 1391* (US); San Sebastian, Cuzco, 25-IV-25, *Pennell 13,628* (F). It is possible that there is a Peruvian entity which is distinct from either of these two species, but that decision must await better material.

10. ARRACACIA TOLUCENSIS (H.B.K.) Hemsl. var. MULTIFLORA (S. Wats.) Math. & Const. Bull. Torrey Club **68**: 121. 1941.

Stout, caulescent, branching, 1–3 m. high, the foliage scaberulous, the inflorescence puberulent; leaves deltoid, 2–3.5 dm. long, ternately decompound, the ultimate divisions linear-oblong to filiform, acute with a prominent callus point, cuneate at base, sessile, distinct or the terminal confluent, 1–6 cm. long, 0.5–4 (–10) mm. broad, entire (in our material), scaberulous on the veins and margins beneath; petioles 1–4 dm. long, sheathing at base; cauline leaves like the basal, the uppermost usually opposite, greatly reduced and often simple, with obsolete sheaths; inflorescence cymosely branched, of several slender peduncles 3–12 cm. long; involucre wanting; involucel wanting, or vestigial; rays mostly 10–25, slender, spreading-ascending, subequal, 1.5–3 cm. long, slightly webbed at base and often puberu-

lent; pedicels short, spreading-ascending, usually 2–5 mm. long, webbed at base and often puberulent; flowers greenish-yellow; stylopodium conic, the styles short, erect or spreading; carpophore 2-cleft to the base, lax; fruit ovoid-oblong, 6–8 mm. long, 3–4 mm. broad, tapering at apex and base, the ribs prominent, acute; oil tubes large, solitary in the intervals, 2 on the commissure; seed channeled under the tubes, the face deeply sulcate.

TYPE: "on the hills at Rio Hondo," Mexico, *Pringle 3620*.

North American distribution: Hidalgo to Durango, south to Mexico (state) and Oaxaca, Mexico.

South American specimens examined: COLOMBIA. MAGDALENA: Páramos of the Sierra Nevada de Santa Marta, about 30 miles inland from Dibulla, ca. 3850 m., VII–32, *W Seifriz 432* (US).

The basis for the recognition of this entity in South America is a single fragmentary, badly molded specimen, but there seems to be no question of its identity. Dr. Seifriz's collecting clearly suggests that additional field work in the mountains of Magdalena might prove exceedingly rewarding.

TAUSCHIA Schlecht. Linnaea **9**: 607. 1834; nomen conservandum. Not *Tauschia* Preissler, 1828.

Two entities from South America have been referred to this genus, which has about twenty species in Mexico and the western United States. The generic lines between *Tauschia* and *Arracacia* have been shifted and redrawn numerous times, and these differences of opinion clearly reveal that there is no sharp morphological break. My recollections of struggling with this problem are still too vivid, however, to make me want to reopen the question now.

1. TAUSCHIA NUDICAULIS Schlecht. Linnaea **9**: 608. 1834.

To my knowledge, this species, known from Jalisco south to Vera Cruz, Mexico (state), and Puebla, has been reported from South America only on the basis of *Spruce 6065*, "in Andibus Ecuadorensibus." According to Coulter and Rose (1900), "Spruce's specimen from South America is similar to the Mexican specimens in habit, but with a somewhat different fruit section and it may yet prove a distinct species." Judging by the sheet at the Gray Herbarium, the differences, if any, are by no means conspicuous. It may be significant that *Ottoa oenanthoides* H.B.K. has a comparable distribution, being known from Guerrero and Oaxaca, Venezuela, Colombia, and Ecuador.

2. TAUSCHIA JAHNII Rose ex Pittier, Man. Pl. Usual. Venez. 299. 1926 (nomen subnudum.).

This name was picked up by Pittier from Rose's annotation of certain Venezuelan collections, of which I have seen the following: "La Puerta, Trujillo, 2000 m.," 16-IX-22, *Jahn 1136* (US) and "Sierra Nevada de Mérida, 10,000–16,000 feet," XII-23, *de Bellard 259* (US). Both collections are fragmentary and appear to agree in all respects, including the lack of any mature fruit. While attempting to match these in the Gray Herbarium, I discovered a third and much better sample, but still fruitless, in *Ghiesbreght 687*, "au bord de ruisseaux et des sources d'eau dans les montagnes, Chiapas, etc., Mexico." Steyermark has recently collected the plant twice in Venezuela: "LARA: between Buenos Aires and Páramo de las Rosas,

2285–3290 m.," 11-II-44, *55,455* (F) and *55,475* (F), likewise in an immature state. Although all these specimens are superficially reminiscent of *Apium graveolens* L., they are apparently much more closely related to *Arracacia edulis* S. Wats. and *Tauschia nudicaulis* Schlecht., and perhaps constitute an undescribed species in one of these two genera, which would be notable for its leafy stems, small umbels, entire bractlets, and small, blunt fruits (immature).[1]

NEONELSONIA Coult. & Rose, Contr. U. S. Nat. Herb. **3**: 306. 1895.

1. NEONELSONIA ACUMINATA (Benth.) Coult. & Rose ex Drude; E. & P. Nat. Pfl. **3**[8]: 167. 1898.

Arracacia acuminata Benth. Pl. Hartw. 187. 1856.

Although this species is commonly confused with *Arracacia Pennellii*, *A. Wigginsii*, and *A. elata* because of a close similarity in vegetative characters, its ellipsoid-cordate, wrinkled fruit and filiform bractlets and pedicels make it readily distinguishable. *Neonelsonia acuminata* is known from Colombia to Ecuador.

2. NEONELSONIA sp.?

To the collection *Pennell 2452*, "Forest, on mount, 2–4 m. s. of Sibate, Cundinamarca, Colombia, 2900–3000 m.," 13,15-XII-17 (NY; F, US—photos), Rose gave an herbarium name under *Arracacia*, presumably in recognition of the laxity of the filiform pedicels. The young fruits are broadly ovoid, but too young to be assigned with any certainty to the proper genus. The general similarity of the collection to the preceding species, however, suggests that it may represent an undescribed species of *Neonelsonia*, distinguished from *N. acuminata* by its mucronate rather than spinulose serrations, acute rather than acuminate leaflets, and shorter and broader bractlets.

MYRRHIDENDRON Coult. & Rose, Bot. Gaz. **19**: 466. 1894.

As revised by Coulter and Rose (1927), this genus contains four species, one in Guatemala and Costa Rica, the second in Panama, and two others in northern South America. The very large linear or oblong and dorsally flattened fruit is ample to distinguish these plants from any species of *Arracacia*, but vegetative material of the two genera is commonly confused.

1. MYRRHIDENDRON GLAUCESCENS (Benth.) Coult. & Rose, Jour. Wash. Acad. Sci. **17**: 214. 1927.

Arracacia glaucescens Benth. Pl. Hartw. 187. 1845.

This is presumably the more common of the two species, being known from Colombia to Ecuador. The almost coriaceous leaves with a raised stipular ring at the base of the petiolules and the dissected bractlets distinguish it from any *Arracacia* known to occur in the same area.

2. MYRRHIDENDRON PENNELLII Coult. & Rose, Jour. Wash. Acad. Sci. **17**: 214. 1927.

[1] While filing the accumulated Umbelliferae in the Herbarium of the University of California, the writer discovered two more collections of this entity in Steyermark's nos. *48,460* and *49,771* from Guatemala. The second of these has semi-mature fruit, and it is clear from a study of these that all the plants mentioned above under *Tauschia Jahnii* Rose are conspecific with *Arracacia vaginata* Coult. & Rose, hitherto known to occur only from Michoacán to Oaxaca, Mexico. Thus *Arracacia vaginata*, with a range extending from Michoacán to Venezuela, constitutes the eleventh species of its genus thus far reported from South America.

Known only from Colombia, this species differs from the preceding in having lanceolate, acuminate, sharply serrate, rather than ovate, obtuse, incised and lobed as well as serrate leaflets, and in having the stipular ring densely hairy.

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FICUS RETUSA L.

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For almost one hundred years after their publication *Ficus retusa* L. and *F. nitida* Thunb. were considered separate species. However, the almost identical receptacles and the presence of some intermediate shapes between the most extreme leaf-blades of these small-leaved forms indicated such a close relationship that some botanists came to believe that there was not even a varietal difference between them.

The first statement that *F. nitida* was a synonym of *F. retusa* seems to have come from Bentham.[1] This opinion was held also by most botanists of the rest of the 19th century, especially those who wrote on India and Australia. However, Miquel in 1867 (see below under *Ficus retusa* var. *nitida*) listed *nitida* as "alpha" under *F. retusa*, although this allocation passed almost unnoticed except for Bureau's[2] citation of it as a synonym of *F. retusa*, and Trimen's[3] report of var. *nitida* in Ceylon. Finally King[4] characterized and illustrated *F. retusa* var. *nitida*, but made no reference to Miquel (1867). King has been cited as the author of var. *nitida* by Domin and others.

Most 20th century botanists have accepted *nitida* as a variety. Exceptions who believed it a species were Warburg and others who mentioned it as a cultivated tree in the Americas. It is impossible to judge the opinions of those who have included *nitida* and its synonyms in the whole synonymy of the species *F. retusa*, unless additional text states their views.

King spoke of the "typical *F. retusa*" as contrasted with var. *nitida*, and Koorders & Valeton (see below under *Ficus retusa* var. *typica*) mentioned similar titles; but Domin was the first to publish a valid name for *F. retusa* exclusive of var. *nitida*.

Both varieties have been collected frequently, and var. *nitida* has been widely planted outside its original distribution. Partly for these reasons the species as a whole has acquired an unusually large number of synonyms: some given as new names, and others as incorrect allocations to already existing species. A few synonyms have long been recognized as belonging to one variety or the other, but the rest usually have been listed under the specific name because of the inadequacy of their descriptions, or their inter-

[1] Fl. Hongkongensis 327. 1861.
[2] Ann. Sci. Nat. V. 14: 250. 1872.
[3] Syst. Cat. Pl. Ceylon 84. 1885.
[4] Ann. Bot. Gard. Calcutta 1: 51. *pl. 62*. 1887–1888.

mediate status between vars. *typica* and *nitida*, or in the belief that the two forms are synonymous.

Since *F. retusa* is an important, although confused and debatable East Indian species, and since var. *nitida* is quite separable from the typical variety by habit as well as leaves it has seemed well to differentiate the synonyms of each form, incidentally eliminating numerous homonyms which have been associated with them. Var. *nitida*, as the more distinctive, will be treated first. In selecting its synonyms the principal characters used are the short, blunt, acuminate apex and the narrowed base of the leaf, as well as its shining upper surface; and the banyan habit. Synonyms which show an insufficient number of these characters, or which do not point towards var. *nitida* by their own synonmy or by the opinions of authorities are relegated for the present to var. *typica*.

The description and distribution of var. *nitida* have been made up from living trees observed at numerous places in Florida, and from herbarium specimens and texts seen mostly at the New York Botanical Garden. Var. *typica* was studied only through herbarium specimens and texts.

The following specimens furnish good examples of the leaves, and sometimes of the receptacles, of var. *nitida: F. nitida* from the Botanic Garden of Calcutta, a part of no. 4523 D in Wallich's catalog; *Urostigma nitidum, Kollmann 1838*, Hongkong; and *F. retusa, R. C. Ching 5185*, Kwangsi Province, China. Good examples of var. *typica* are: *F. retusa, L. J. Brass 3592*, Papua; *Urostigma nitidum, W. C. 2651, Campbell 82*, Peninsular India (from the Wight herbarium); *F. retusa, A. W. Herre 378*. Celebes; and *F. retusa, W. J. Lutjeharms 4212*, S. Sumatra.

Illustrations of leaves, receptacles, and flowers of both varieties may be seen in King's text (1887–1888; **1**: *pls. 61, 62, 84*). Leaves of var. *typica* are shown in *Hawaiian Forester and Agriculturalist* **6**: *pl. 125*. 1909. *Pl. 732* in the *Atlas* of Koorders & Valeton (1916) bears leaves and receptacles of var. *nitida*, although some leaves are labeled merely *F. retusa*. Mowry[5] pictures var. *nitida* under the name *F. retusa* (*F. nitida* Thunb.). *Sata*[6] illustrates var. *typica*.

FICUS RETUSA var. NITIDA (Thunb.) Miq. Ann. Mus. Bot. Lugd.-Bat. **3**: 288. 1867.
Itti-arealou Rheede, Hort. Mal. **3**: 69. *pl. 55*. 1682.
Ficus malabarica, folio mali cotonei, fructu exiguo, sanguineo, plano-rotundo J. Comm. in Rheede, Ibid. **3**: 70. 1682.
Garden mangrove Hughes, Nat. Hist. Barbadoes 193. 1750.
F. microcarpa L.f. Suppl. Pl. 442. 1781. Not of Vahl, Blume 1825, or F. Villar.
F. nitida Thunb. Diss. Fic. 5, 10–11, 15. 1786. Not of Heyne Hb. ex Roth, or Hook. 1825.
F. beniamina Thunb. Ibid. 11. 1786. Not of L.
? F. retusa Lam. Enc. **2**: 496. 1788. Not of L.

[5] Fla. Agr. Extens. Bull. **95**: *f. 42*. Ap. 1938.
[6] Contr. Inst. Hort. & Econ. Bot. Taihoku Univ. **32**: *pls. 18, 19*. 1944.

F. pertusa Willd. Sp. Pl. **4**: 1144. 1806. Not of L. f., Bory, or of some writers on W. I. and Mexico.
F. rubra Roth in Roem. & Schult. Syst, Veg. **1**: 507. 1817. Not of Vahl or Blume.
F. indica Heyne Hb. ex Roth, Nov. Pl. Sp. 391, as syn. 1821. Not of L. or Miquel.
F. arbutifolia Link, Enum. **2**: 450. 1822.
F. condaravia Hamilt. Trans. Linn. Soc. **15**: 131. 1827.
F. reflexa Hamilt. Hb.; Wall. Cat. no. 4523 F. 1831. Not of Thunberg.
F. pallida Wall. Cat. no. 4567. 1831. Not of Vahl or Grisebach.
F. pallescens Steud. Nom. Bot. ed. 2. **1**: 637. 1840.
F. nitida β *reflexa* Steud. Ibid.
Urostigma nitidum Gasp. Nov. Gen. Fic. 7. 1844. *Nomen nudum.*
U. amblyphyllum Miq. Hook. Lond. Jour. Bot. **6**: 569. 1847.
U. pisiferum Miq. Ibid. **6**: 580. 1847.
F. pisifera Hook. Hb. ex Miq. Ibid., as syn. Not of Wallich.
U. nitidum Miq. Ibid. **6**: 582. 1847.
F. elliptica Hook. Hb. ex Miq. Ibid., as syn. Not of H. B. K., Miquel 1848, or Grisebach 1860.
U. microcarpum Miq. Ibid. **6**: 583. 1847.
U. arbutifolium Miq. Versl. Med. Kon. Akad. Amsterdam **13**: 412. 1862.
F. prolixa Vieill. & Depl. Ess. Nouv. Calédonie 114. 1863. Not of Forster f.
F. amblyphylla Miq. Ann. Mus. Bot. Lugd.-Bat. **3**: 286. 1867.
F. retusa α *nitida* Miq. Ibid. **3**: 288. 1867.
F. retusa γ *pisifera* Miq. Ibid. **3**: 288. 1867.
F. rubra var. *amblyphylla* Baker, Fl. Mauritius 285. 1877.
F. sp. Combs, Trans. St. Louis Acad. Sci. **7**: 465. 1897.
F. bengalensis Schimp. Pfl. Geog. ed. 1. *pl. 162.* 1898. Not of L.

Glabrous shrub or tree to 25 or 30 m. in native home; banyan type, with secondary trunks originating from aerial roots starting from the first stem and the largest branches and fastening themselves in the ground; young trunks light-colored, unfurrowed, branching near ground, developing prop roots and buttresses; crown very spreading; branches sometimes striate or angular; twigs slightly 3-angled, tan-colored with light-colored lenticels; terminal buds conical-subulate, green, about 2 cm. long; leaves evergreen; petioles mostly about 5–10 mm. long, slender, grooved, lighter green than blades when fresh, darker when dry; blades laurel-like, typically obovate, but also elliptic or ovate; many about 7.5×3.5 cm., but to 12.5×5.5 cm.; apex slightly narrowed and then rather abruptly short-blunt-acuminate; base tapering to petiole; margin entire, cartilaginous; upper surface dark green, waxy, shining; under surface paler, dull; texture thin-leathery; veining distinct beneath when dry; midrib continuous; one pair of basal veins not much thicker than the lateral veins, parallel to the margin and reaching almost the middle of the blade; 4–7 sets of slender, almost parallel lateral veins, leaving the midrib at an upper angle of 40–50° and uniting in indentations with the submarginal vein; several forked thinner veins in each intervein, parallel to the lateral, reaching the submarginal vein at slight indentations; reticulum faint; receptacles axillary, paired but sometimes appearing crowded, on new wood, depressed-globose, 5–6 or rarely to 8 mm. in diameter, glabrous; apex slightly raised at first, ostiole closed by 3 close triangular bracts; base rounded, becoming red, purple, or blackish, sessile in a flat inconspicuous cup made by 3 ovate basal bracts; flowers (according to Gagnepain) of all three kinds in one receptacle, short-pedicelled, 3–4 sepals;

sepals of male flowers obovate, spatulate, about one mm. long, very obtuse; stamen one, anther short-mucronate; sepals of female flowers ovate, obtuse, 1–2 mm. long; ovary oblong, then pyriform, 2 mm. long; style lateral, filiform, dilated and slightly papillose at summit; (gall flowers not mentioned).

TYPE: none cited by Thunberg. (See comment on *F. nitida* Thunb., below).

Distribution: northeastern India and some states to the north, Burma, Indo-China, Malaya, South China, Formosa, Philippines, Caroline Islands, Australia, New Caledonia.

Common Names: laurel fig, shining fig-tree; Spanish, Cuban, and Indian laurel; small-leaved, bastard and Chinese banyan. From the prevalence of this variety Fuchow (South China) has been called the Banyan City.

Economic Importance: the ease with which var. *nitida* can be propagated by cuttings from its aerial roots may be responsible for its wide distribution as a cultivated tree. When it is used along streets its aerial roots must be cut off to keep the tree within bounds.

FICUS RETUSA var. TYPICA Domin, Bibl. Bot. **89**: 563. 1921.
F. retusa L. Mant. 129. 1767.
Perula retusa Raf. Sylv. Tell. 58. 1838.
Urostigma retusam Gasp. Nov. Gen. Fic. 7, 1844. *Nomen nudum.*
U. retusum Miq. Hook. Lond. Jour. Bot. **6**: 581. 1847.
U. ovoideum Miq. Ibid. **6**: 581. 1847.
? *U. accedens* β *latifolia* Miq. Fl. Ind. 1^2: 347. 1859.
F. dilatata Miq. Ann. Mus. Bot. Lugd.-Bat. **3**: 218. 1867.
F. retusa β *ovoidea* Miq. Ibid. **3**: 288. 1867.
F. retusa genuina King ex Koord. & Val. Booms. Java **11**: 38. 1906.
F. retusa forma *typica* King ex Koord. & Val. Ibid. **11**: 133. 1906.
F. retusiformis Lév. Fedde, Repert. **8**: 549. 1910.
F. retusa var. *retusa* Haines, Bot. Bihar & Orissa 829. 1924.

(It will be noticed that some of the above synonyms are incorrect in form. They are cited to show that several attempts were made to form a variety correlative with *nitida*.)

In comparison with var. *nitida* the typical form of *F. retusa* has at the most only a few air roots, and usually none which forms a secondary trunk. The dull-surfaced leaves commonly are rather broad-ovate or broad-elliptic instead of obovate, and have an obtuse, apicular, or barely elongated apex and a rounded or very slightly narrowed base. The receptacles may reach 10 or even 13 mm. in diameter. Their basal bracts seem to be larger and more spreading than those of var. *nitida*, and tend to remain on the twig after their receptacles have fallen off. The female flowers are described by King as almost or quite sessile. The gall flowers, according to Sata (1944; pt. 1: 23), have a globose ovary, a short style, and a cylindric or clavate stigma.

TYPE: India.

Distribution: Peninsular India; also about the same distribution as var. *nitida*, except for Java, according to reports and specimens.

Common Names: Blunt-leaved fig, retuse fig.

Economic Importance: latex furnishes some rubber, bark said to be used in paper-making, tree cultivated as decoration for lawns and streets.

EVALUATION OF SYNONYMS OF VAR. NITIDA

Itti-arealou Rheede. The first published mention of a tree known to belong to *F. retusa* is believed to be the description, accompanied by a plate, of *Itti-arealou*. The text is so occupied by an account of its banyan habit, most of it taken from the description by Clusius of *F. indica* (*F. bengalensis* L.), that it dismisses the leaves with the remark that they are similar to, but smaller than those of *Itti-alou*, (a tree often confused with *F. retusa*, but usually believed to be the prototype of *F. benjamina* L.) Rheede's plate of *Itti-arealou* pictures leaves of the *typica* form, but with longitudinal parallel veins. Since such veining almost never is seen in *Ficus* the assumption is that the artist was told to depict parallel veins, but was not shown the direction in which they should run. The receptacles are represented satisfactorily in both text and plate. In spite of the leaf-form and the location of the tree in the southwestern part of India this reference, which Thunberg cited for *F. nitida*, has been almost universally accepted because of the banyan habit, which Rheede further emphasized by citing vernacular names meaning "Little Root-Tree".

Commelin's polynomial. At the end of Rheede's text the editor, J. Commelin, furnished a descriptive name for *Itti-arealou*, in which the characterization of the leaf as quince-like was drawn from Clusius and was inaccurate as to both shape and surface.

Garden Mangrove. Less than 70 years after the publication of *Itti-arealou* Hughes declared that the Garden Mangrove of Barbados was a kind of fig-tree which could be propagated by its aerial roots. This has been identified by Maycock[7] as "*F. nitida.*" Hughes' probably was almost the first of many reports of this variety in the West Indies.

Synonyms from Thunberg. Thunberg's description of *F. nitida* added little except the word *shining* to Rheede's text. In fact, his characterizations of the leaves and receptacles were merely those of Rheede's plate, translated into words. Thus he omitted the distinguishing characters of leaf-shape and banyan habit. However, Willdenow[8] reported the leaves as obovate, very short-obtusely acuminate, dark green above, and 5 cm. long. Vahl[9] called them acuminate at each end.

Although Thunberg listed no location of his type of *F. nitida*, merely implying that it came from Malabar, he may have intended Rheede's species simply as a reference. According to Aiton[10] specimens of *F. nitida* were introduced into Kew Gardens in 1786 (the year of Thunberg's publication) from the East Indies by Sir Joseph Banks. There is a possibility that these specimens came from one of the large East Indian islands touched by Banks, perhaps Java, where, according to Koorders & Valeton (1906; 11: 114–116) the typical Himalayan form of *F. retusa* L. breaks up and encroaches on var. *nitida*, and the latter is very common. Thunberg may have come across *F. nitida* from that source: a more likely one than the southwestern coast of India proper. In that case the question is: how did

[7] Fl. Barbadensis 406. 1830.
[8] Sp. Pl. 4: 1145–1146. 1806.
[9] Enum. Pl. 2: 191. 1806.
[10] Hort. Kewensis ed. 2. 5: 488. 1813.

var. *nitida* get to Malabar, if *Itti-arealou* really is Thunberg's species? One answer is that it may have been imported because it was an interesting and easily propagated tree, just as it came so early to the West Indies that it was reported by Hughes in 1750 as a 40-ft. tree whose cultivation already was understood.

A more valuable contribution to var. *nitida* from Thunberg was his description of what he thought was *F. benjamina* L. This seems to have been based upon a specimen from a Javan tree which Thunberg later sent to van Royen. Although Thunberg referred to Linnaeus he listed few characters given by that author, but repeated some of his own which he had stated for *F. nitida*. *F. microcarpa* L.f. was cited as a synonym.

The Thunberg specimen of "*F. Beniamina*", which later came into Blume's possession, was declared by Blume (below) to be *F. microcarpa*, and this, as will be shown, is var. *nitida*. Miquel (1867) cited *F. benjamina* of Thunberg as a synonym of var. *nitida*, and King (1887-1888; **1**: 180) has said that it probably belongs there. Other authors whose reports of *F. benjamina* should be allocated to var. *nitida* are Willdenow (1806; **4**: 1143), Willdenow,[11] Persoon,[12] and Kunth,[13,14] Roxburgh[15,16] usually is included in this list because of the suggestion of Wight[17] that Roxburgh's description in 1832 of *F. benjamina* Willd. might be of *F. nitida*. Although *pl. 657* in Wight's book, labeled *F. nitida* and supposed to represent Roxburgh's tree, resembles var. *typica* in leaf-shape, as does the specimen *Urostigma nitidum* from Wight's herbarium (already mentioned), Wight's text says that *F. nitida* has secondary trunks. Cooke[18] has said that *F. benjamina* Graham[19] is *F. retusa*. Since Cooke included *F. nitida* as a synonym of *F. retusa*, and since Graham mentioned shining polished leaves, the latter's *F. benjamina* probably belongs to var. *nitida*.

F. retusa Lamarck. The inclusion of this name as a synonym rests upon very slight evidence; that is, that the branch seen by Lamarck came from Java (where *nitida* and not *typica* is the usual variety). It would be impossible to cite all the references which have called var. *nitida* by the name of *F. retusa*.

F. microcarpa. Between the dates of publication of *F. retusa* and *F. nitida* the younger Linnaeus described *F. microcarpa* from Java. This was cited as a synonym of *F. benjamina* by Willdenow (1806) and others, as well as by Thunberg, although Willdenow (1809; suppl. 69) listed it as a species without description. In 1810 J. E. Smith[20] cited it as a synonym of *F. nitida*.

The reference which did most toward allocating *F. microcarpa* L. f to

[11] Enum. Hort. Berolinensis 1063. 1809.
[12] Syn. Pl. **2**: 610. 1807.
[13] Ind. Sem. Hort. Berol. 1846: 20. 1846.
[14] Ann. Sci. Nat. III. **7**: 250. 1847.
[15] Hort. Bengalensis 103. 1814.
[16] Fl. Ind. ed. 2. **3**: 550. 1832.
[17] Ic. Pl. Ind. **2**: (4) 1. 1843.
[18] Fl. Pres. Bombay **2**: 647. 1907.
[19] Cat. Pl. Bombay 191. 1839.
[20] Rees, Cycl. **14**: Ficus no. 50. 1810.

var. *nitida,* and toward filling in at an early date the distinguishing characters of that variety was the work of Blume,[21] in 1836. Blume[22] already had described as *F. microcarpa* a climbing vine, now believed to be *F. ramentacea* Roxb., but to this he did not refer in 1836. He based the later material upon a very old Javan tree which he thought was made up by the intertwining of *F. microcarpa* and *F. benjamina* L. He said that Thunberg had not differentiated the two species, but had called the composite plant *F. benjamina;* and that the specimen sent by him to van Royen was *F. microcarpa, which* (Blume said) had been commonly confused also with *F. nitida* and sometimes with the (South) American species *F. pertusa L.f.*

Although Blume thus rather hesitatingly differentiated *F. microcarpa* from *F. nitida* his description of the former, his comparisons of it with *F. benjamina* and other species, and his reference to *Itti-arealou* Rheede as a synonym served to direct *F. microcarpa* toward var. *nitida.* Miquel (1867) cited it as a synonym of *F. retusa a nitida,* and other botanists have accepted it as belonging to the species *F. retusa.* Its specific name would supplant *nitida* if the latter were considered a species.

F. pertusa. Under this name a shrub from Surinam (Dutch Guiana) was described briefly by Linnaeus f.[23] in almost the same terms that applied also to var. *nitida,* except for smaller and peduncled receptacles. The individuality of this species is shown in a plate of Plumier's,[24] cited by the younger Linaeus as a reference, which agrees well enough with two specimens of *F. pertusa: Otto Kuntze Hb. from* "Mattagrosso" (Matto grosso, Brazil?), and *W. E. Broadway 8169* in a collection from the Royal Botanic Gardens, Trinidad and Tobago, W. I. These show elliptic rather than obovate leaves, with many more lateral veins than in var. *nitida.* Both the plate and the second specimen have peduncled receptacles.

In spite of these differences *F. nitida* commonly was called *F. pertusa* in herbaria of the West Indies, according to Warburg[25]. He also asserted that *F. sp.* Combs, and *F. pertusa* of Willdenow (1806) and of A. Richard[26] were *F. nitida.* Similar synonyms, listed by Maycock (1830; 407), were *F. pertusa* of Aiton (1813; **5**: 487) and of Sprengel.[27] To them probably should be added reports of *F. pertusa* by Willdenow,[11] Roth (1821; 288), Link (**2**: 449), and Kunth[13] and (1847; 249-250). But the earlier text on *F. pertusa* by Aiton[28] bears evidence that it refers to the species of Linnaeus f.

F. rubra. The source usually given for *F. rubra* Roth is Roth's *Novae plantarum species* 391. 1821. But this name had been published previously by Roemer & Schultes, who referred to Roth's manuscript. *F. rubra,* without the references cited by Roth, and with the omission of his variety *acuminata,* was allocated to var. *nitida* by Miquel (1867). King (1887–1888; **1**: 179) also has stated that *F. rubra* Roth belongs to that variety.

[21] Rumphia **2**: 17–21. 1836.
[22] Bijdr. 442. 1825.
[23] Suppl. Pl. 442. 1781.
[24] Pl. Amer. *pl. 132 f. 2.* 1755.
[25] Urban, Sym. Antillanae **3**: 489. 1903.
[26] Sagra, Hist. Cuba **11**: 221. 1850.
[27] Syst. Veg. **3**: 781. 1826.
[28] Hort. Kewensis ed. 1. **3**: 452. 1797.

F. indica. Roth based *F. rubra* upon an East Indian herbarium specimen which Heyne had called *F. indica.* The original *F. indica* was the name which Theophrastus gave to the huge banyans seen in the Indian Punjab by the army of Alexander the Great. The references cited by Linnaeus show that his *F. indica* in *Species plantarum* is the same species. However, Linnaeus, who apparently never had seen *F. indica,* unwittingly gave the title *F. benghalensis* (*F. bengalensis* is incorrect spelling) to a plant of the same species, which he had studied in Leiden, and which had been described and illustrated under different names by other botanists. In time it was realized by later writers that *F. indica* and *F. bengalensis* were the same, and the latter name was perpetuated, partly because of its better descriptions and references, but principally because *F. indica* L. had been given a variety, β, by Linnaeus, which was a conglomeration of several American species, mostly from the West Indies, of a tree from Amboina, and of *Tsiela* Rheede, a species now usually known as *F. tsiela* Roxb., but more correctly entitled *F. amplissima* J. E. Smith.

F. indica had almost disappeared from taxonomy when Miquel (1867; **3**: 263, 287) revived it as the title of a Philippine specimen which he previously had called *Urostigma tjiela* and had assumed was a narrow-leaved form of *Tsiela* Rheede. This slight and erroneous connection with one of the Linnean synonyms of a name which very properly had been discontinued seems to have been Miquel's only reason for the use of the term *indica.* In apparent violation of the rules of botanical nomenclature *F. indica* as a title has been employed by such authorities as King, Merrill, and others.

This explanation is made necessary by the appearance now and then of herbarium specimens named *F. indica* which resemble one or the other varieties of *F. retusa* rather than the Philippine *F. indica* of Miquel. Certain references in literature also suggest an occasional misnomer.

F. arbutifolia. Warburg[29] and Britton & Wilson[30] have cited *F. arbutifolia* Link as a synonym of *F. nitida.* Link's description was brief but suggestive of var. *nitida.* A detailed characterization by Kunth (1846; 19. 1847; 249) was complicated with a large number of horticultural and questioned synonyms, which seem unimportant or incorrect. No distribution was reported by Link, Kunth, or Miquel (who increased the synonymy). Warburg's Berlin connections probably caused him to recoginze this species as the *F. nitida* which he had seen in the West Indies and elsewhere.

F. condaravia. This species was said by Hamilton to be the same as *Itti-arealou* Rheede and *F. nitida* Thunb., and its description bears out that allocation. King (1887–1888; **1**: 180) declared that *F. condaravia* appeared to be *F. retusa,* but did not specify the variety.

F. reflexa. This specimen from Hamilton's herbarium was placed by Wallich, with a question mark, under *F. nitida.* Steudel considered it a variety of that species and suggested a comparison with *F. condaravia.* King (1887–1888; **1**: 50) cited *F. reflexa* and the other sections of Wallich's no. 4523 as synonyms of *F. retusa.*

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[29] Urban, Symb. Antillanae **4**: 198. 1905.

[30] Sci. Surv. P. Rico **5**[2]: 239. 1924.

F. pallida Wall. has been accepted for *F. retusa* by King. As the specific name had been published for a different *Ficus* by Vahl, Steudel changed Wallich's title to *F. pallescens*. Thwaites[31] allocated *F. pallida* Wall. with *F. nitida* Thunb. and *F. retusa* L. to *Urostigma retusum*, and Miquel (1867) accepted it as a synonym of *F. retusa* γ *pisifera* on Thwaites' authority.

Species of *Urostigma* and their later allocations. Gasparrini in 1844 and later[32] listed "*retusam*" (*retusum*) and *nitidum* under his new species *Urostigma;* but failed to mention the original authors. Therefore the credit for these names passed to Miquel (1847), who was responsible also for other species of *Urostigma* related to *F. retusa*. Bentham[1] cited most of them as synonyms of *F. retusa*, and Miquel (1867) listed them as distinct species or as varieties of *F. retusa*.

U. amblyphyllum was described from an East Indian specimen in Hooker's herbarium which was labeled *F. nitida*. In spite of the blades's obtuse or slightly retuse apex and its obtuse or slightly emarginate base King (1887–1888; **1**: 179) asserted that *U. amblyphyllum* and *F. amblyphylla* were synonyms of *F. rubra* Roth which, he said, equalled *F. retusa* var. *nitida*. Baker previously had allocated *U. amblyphyllum* to *F. rubra* as a variety.

The basis of *U. pisiferum* was *F. pisifera* Hb. Hook., although *F. condaravia*, omitting synonym *Itti-arealou*, also was cited. Miquel eventually called this form *F. retusa* γ *pisifera* without further description, but his original characterization and Hamilton's synonym suggest that it belongs to var. *nitida*. A synonym added to it in 1867 is *F. pallida Wall.*, which would carry with it *F. pallescens* Steud. (see above). *U. pisiferum* is acknowledged as *F. retusa* by many authorities.

Miquel's treatment of *U. nitidum* in 1847 included synonyms and references mentioned by others, and also two specimens from Hooker's herbarium, labeled *F. nitida* and *F. elliptica*. The latter is not to be confused with a parasitic vine from the Philippines, to which Miquel[33] later gave the name *F. elliptica*. Somewhat the same material was repeated by Miquel in 1859; but in 1867 the form was considered by him a variety of *F. retusa*.

The discussion of *U. microcarpum* by Miquel (1847) and later (1859; **1**[2]: 346) was mainly a summary of that of Blume (1836) for *F. microcarpa* L.f. (above). Two synonyms cited by Miquel apparently do not apply to var. *nitida*, of which *F. microcarpa* is a synonym. These are *F. littoralis* Blume which Blume suggested as a variety of *F. microcarpa*, but which seems unlike the species *F. retusa;* and *F. leptocarpa* Steud., which Miquel himself removed in 1867 when he transferred the *microcarpa* forms to *F. retusa* α *nitida*. *F. leptocarpa* probably is *F. ramentacea* Roxb. *F. littoralis* possibly is var. *typica*.

U. arbutifolium was returned to *F. arbutifolia* Link by Miquel (1867; **3**: 298). This reference contained only Kunth's suggestions as to synonyms of *F. arbutifolia* (see above), with one omission; and included one horticultural and one herbarium synonym of Miquel's own.

F. prolixa at first was thought to be the species to which Forster f. had

[31] Enum. Pl. Zeylandiae 265. 1864.
[32] Rendic. Acad. Napoli **4**: 398. 1845.
[33] Fl. Ind. Batavae **1**[2]: 345. 1859.

given that name; but later was identified by Bureau[2] as *F. retusa* var. *nitida*. Specimens had been found in New Caledonia.

F. sp. Combs. A collection note reported this only as a large tree in Cuba, perhaps cultivated. It was allocated to *F. nitida* by Warburg.[25]

F. bengalensis Schimp. The mislabeling of this picture of a banyan was corrected to *F. retusa* var. *nitida* by Koorders & Valeton (1906; **11**: 112, 114) and a plate labeled *F. retusa* was substituted for it in the Faber edition of Pflanzengeographie **1**: *pl. 128*. 1935.

EVALUATION OF SYNONYMS OF VAR. TYPICA

F. retusa L. The original Linnean description of *F. retusa* contains the leaf-character cuneiform-obovate, which is more typical of var. *nitida* than of var. *typica*. But because it also speaks of the leaves as *oblong*, a term sometimes used by early botanists to denote *elliptical*, and of their apex as very obtuse this text has been thought to apply to var. *typica*. Specimen *T.M. Tsui 373* from Kwangtung, China has a cuneiform-obovate leaf-shape and an almost perfectly obtuse apex. It is labeled *F. retusa* and evidently is var. *typica*. *Retuse* now means notched when applied to leaves and seems inappropriate here, although very rarely it has been stated as one of their characters. Thunberg's description of *F. nitida* calls the receptacles retuse-umbilicate, probably referring to their eventually depressed apex. Léveillé says that *F. retusiformis* has retuse receptacles.

Perula retusa represents one of Rafinesque's attempts to break up the huge genus of *Ficus*. *F. retusa* was the type of his genus *Perula*.

Miquel's synonyms. Since Gasparrini's *Urostigma retusam* cited no author for the specific name that combination is credited to Miquel.

The classification of *U. ovoideum* as a synonym of *F. retusa* has been made by several authors, including King, but is perplexing, since most of its synonyms and references cited by Miquel belong to other species. The specific name was derived from Jack[34] and from a specimen named *F. ovoidea* Jack which was listed in Wallich's catalog as no. 4526 (incorrectly stated by Miquel as no. 4524). These references have been declared by King (1887–1888; **1**: 51) to be a form of *F. diversifolia* Blume. The citation which has directed *U. ovoideum* towards *retusa* is Miquel's of Wallich's no. 4530 B, which Wallich placed under *F. retusa*. This Miquel had not seen, but it is confirmed as *F. retusa* by King and others. In 1859 (**1**[2]: 345) Miquel said that *U. ovoideum* was like *U. nitidum*, but in 1867 he listed it as a separate variety of *F. retusa*. According to his descriptions it seems to be an intermediate form between var. *typica* and var. *nitida*, and here is placed under the former.

F. dilatata Miq. is listed as a synonym of *F. retusa* by King. Miquel's description obviously is of var. *typica* and states that it is near *F. retusa*.

U. accedens β latifolia was cited by Miquel (1867; **3**: 288) as a synonym of *F. dilatata*.

Retusa forms mentioned by Koorders & Valeton. These authors, who

[34] Malay Misc. **2**: 71. 1820–1822. Reprinted in Calcutta Jour. Nat. Hist. **4**: 224–225. Ap. 1843.

usually accepted King's judgments on *Ficus*, did not think highly of his identifications of Javan specimens of *F. retusa*. They said (1906, **11**: 113) that King determined a five-fold example in Koorders' herbarium as *F. retusa* forma *typica*, although only one specimen was *F. retusa*, and that differed from var. *nitida* only in wider leaves. Of the other specimens two were *F. indica* (Miquel's *F. indica*, see above), and two were *F. calophylla* Blume. On p. 38 Koorders & Valeton had said much the same about King's identification of *F. retusa genuina*. They quoted (p. 114) a statement by Koorders that var. *nitida* was the only Javan form in which secondary trunks were formed from air roots and from branches which forced themselves into the ground, rooted, and made new trunks.

F. retusiformis Léveillé has been definitely allocated to *F. retusa* by Rehder.[35] It was described from south China.

Haines' synonym is in incorrect form, but was made to differentiate the typical variety from var. *nitida*, which he also mentioned.

INCORRECT OR DOUBTFUL ALLEGED SYNONYMS OF SOME FORM OF F. RETUSA

F. benjamina Lour. = *F. benjamina* var. or *?F. indica* Miq.
F. cotoneaefolia var. *b.* Roem. & Schult. = ?
F. indica var. Lam. = ?
F. indica fructu et foliis minoribus Plum. MS 7, no. 109 ex Lam. = ?
F. leptocarpa Steud. = ? *F. ramentacea* Roxb.
F. littoralis Blume = ? *F. retusa* var. *typica*.
F. magnoliifolia Blume = *F. nervosa* Heyne ex Roth.
F. microcarpa var. *littoralis* (Blume) Blume = ? *F. retusa* var. *typica*.
F. naumannii Engl. = *F. retusa* according to Schumann & Lauterbach, but receptacles are peduncled and flowers do not agree.)
F. ovoidea Jack = *F. diversifolia* Blume.
F. pyrifolia Burm. f. = *F. erecta* Miq.
F. retusa var. *macrocarpa* Kurz. (King could not identify this.)
Itty-Alu Rheede = *F. benjamina* L.
Urostigma littorale (Blume) Miq. = ? *F. retusa* var. *typica*.
Varinga parnifolia alt. Rumph. = *F. benjamina* L.
Varinga rubra Rumph. = ?, near *F. calophylla* Blume.

SUMMARY

The close relationship between *F. retusa* L. and *F. nitida* Thunb. was not recognized in botanical literature until almost one hundred years after their publication. For more than 50 years after the latter was published by Miquel as a variety of the former no legal varietal name was given to distinguish the type of *F. retusa*.

Of the two varieties *nitida* seems to be the commoner and the more widely distributed, as well as the more distinctive. It is differentiated from var. *typica* by its leaves with their cuneate base and short blunt acumen, and also by the secondary trunks produced from its aerial roots. The latter aid in its propagation, and so in its artificial distribution. Both varieties are found in India, Malaya, south China, and the islands of the south-

[35] Jour. Arnold Arb. 17: 74. 1936.

western Pacific Ocean; but var. *typica* seems to have a wider natural distribution in peninsular India, and var. *nitida* is much more prominent in Java.

F. retusa sometimes is confused with another common East Indian fig-tree, *F. benjamina* L., which , however, is differentiated from it by its habit and leaves. The branches of *F. benjamina* droop, and the scanty aerial roots do not form trunks. The leaves have a broad base, an apex with a triangular and sometimes twisted acumen about 1 cm. long, inconspicuous basal veins, and numerous fine, parallel, lateral veins.

From the many synonyms of *F. retusa* those belonging to each variety have been selected, evaluated and segregated, usually with the help of such authorities as Miquel, King, and Warburg. Some synonyms have been rejected, and some homonyms have been removed from the host of names associated with the species. New descriptions from living trees of var. *nitida* in Florida and from texts and herbarium specimens of both varieties have been made.

MONTCLAIR, NEW JERSEY

BULLETIN OF THE TORREY BOTANICAL CLUB

VOL. 76, NO. 1, PP. 65–68 JANUARY, 1949

TORREYA

PROCEEDINGS OF THE CLUB

Minutes of the Meeting of May 4, 1948. The meeting, at Columbia University, was called to order at 8: 10 P.M. by President Small; 37 members and friends were present. The minutes of the preceding meeting were read and approved.

The following were elected to membership in the Club: Active Members: Paul R. Burkholder, New Haven, Conn.; Alexander Christoff, Sofia, Bulgaria; Bento Dantas, Pará, Brazil; Arshalus Demerjian, Yonkers, N. Y.; Regina M. Duffy, Jersey City, N. J.; Frederick D. Inge, Hampton, Va.; Peklo Jaroslav, Prague, Czechoslovakia; George H. M. Lawrence, Ithaca, N. Y.; Robert S. Lowry, E. Lansing, Mich.; Marjorie Mutchler, Bayonne, N. Y.; Jaques Rousseau, Montreal, P. Q.; Roy Stutzman, Prescott, Wis.; Associate Members: C. Raymond Brodix, New York, N. Y.; Mrs. Marshall D. Harrington, Madison, N. J.; Sylvia Stein, New York, N. Y.; Sophie K. Wolf, Brooklyn, N. Y.

Dr. W. J. Robbins of The New York Botanical Garden then gave his "Observations on a trip to Japan"—an account of some of the experiences of a group of six scientists (of whom he was one) sent to make a study of the organization of science in Japan, with a view to its being rendered more democratic.

The meeting was adjourned at 9: 25.

Minutes of the Meeting of May 19, 1948. The meeting was called to order by President Small at 3: 00 P.M. at the Boyce Thompson Institute for Plant Research; 53 members and friends were present. Dr. P. W. Zimmerman, who had arranged the program, presented time-lapse motion pictures of plant movements. Demonstrations and discussions were provided of submerged growth of mushroom mycelium, preparation of insecticides from essential oils, methods of measuring O_2 consumption and CO_2 production, methods of increasing duration of life of pollen, seed dormancy, effect of various substances on plant growth, and methods of evaluating fungicides. At the conclusion the club visited the grounds, especially to see the planting of tree peonies. No business was transacted.

Minutes of the Meeting of October 5, 1948. The meeting, at Hunter College, was called to order by President Small at 8: 15 P.M.; about 40 members and friends were present. The minutes of the two meetings preceding were read and approved.

The following names were presented for election to membership: Honorary Life Member, Michael Levine, New York, N. Y. Life Member, Joseph Monachino, New York, N. Y. Active Members: William H. Baker, Corvallis, Ore.; John B. Carpenter, Lima, Peru; C. W. Hesseltine, Pearl River, N. Y.; Henning Horn af Rantzien, Stockholm, Sweden; Barbara F. Palser, Chicago, Ill.; Mildred Pangburn, Hackettstown, N. J.; Karl Silberschmidt, São Paulo, Brazil. Associate Members: Ida Berleant, New York, N. Y.; Ruth A. Beyer, Philadelphia, Pa.; Barbara B. DeHondt, Bayside, N. Y.; Martha Dresner, New York, N. Y.; Marcia A. Everett, Belvidere, N. J.; Joan Feld, Brooklyn, N. Y.; Varian Fry, New York, N. Y.; Mary A. Gonshorel, Brooklyn, N. Y.; Marie A. McAleer, Flushing, N. Y.; Simon D. Messing, New York, N. Y.; Mrs. C. A. Miller, Summit, N. J.; John B. Sangree, Glassboro, N. J.; Helen J. Schwarz, New York, N. Y.; Francis E. Wiederspahn, Springfield, N. J.; Dominick A. Zolla, Madison, N. J. It was moved, seconded, and carried without dissent that they be elected.

The members present were then asked to report on botanical activities of the past summer. Dr. M. A. Johnson discussed the summer foray of the Club and the Botanical Society of America in New Jersey. Dr. M. F. Buell described a study of an undisturbed area of eastern deciduous forest in Minnesota. Dr. H. W. Rickett reported on his study of Bradbury specimens in England, and on the nomenclatorial conference at Utrecht. Dr. Lela Barton discussed briefly the views expressed at the Washington meetings of the A.A.A.S. on science and the outlook for civilization, and papers read at the Botanical Society meetings on embryo culture. Dr. H. H. Clum reported on the physiologists' meetings at Cincinnati, and on work there described on growth-promoting substances and weed-killers and on photoperiodism. Dr. G. H. Shull described seedling albino specimens of *Quercus macrocarpa*. Mr. James McGrath gave an account of a collecting trip to the southern Appalachians and southeastern coastal plain. Miss Lois Wenman described a visit to the Nevada mountains. Miss Hester Rusk reported observation of the opening of evening primrose flowers.

The meeting then rose for refreshments.

Respectfully submitted,

DONALD P. ROGERS,
Recording Secretary

NOTES

A new botanical journal has appeared; by name *Physiologia plantarum*. It is the official publication of the Scandinavian Society for Plant Physiology. It is announced as a quarterly, each issue to contain about 100 pages. Vol. 1, Fasc. 1, p. 1–112, was received in New York on 12 July 1948; Fasc. 2, p. 113–205, on 5 August. Eighteen articles are contained in these two parts, dealing with a variety of topics in plant physiology. A striking and (for us) convenient feature is that all are written in English, though they originated in Stockholm, Uppsala, Lund, Copenhagen, and Helsinki.

Another rare botanical work has been republished by the photo-offset method. It is Rafinesque's *Précis des découvertes et travaux somiologiques*. It contains a "Foreword" by E. D. Merrill, but in other respects follows faithfully the original edition of 1814, published in Palermo "aux dépens de l'âuteur." (The page is slightly enlarged in the reproduction.) "In it appear [to quote Dr. Merrill] very abbreviated descriptions of 110 new species of animals in various groups . . . and 79 new species of plants, as well as various new genera in both groups." Only six copies are recorded in American libraries.

"Somiologie", it should be observed, was the name Rafinesque gave to the science of living bodies, embracing both botany and zoology; perhaps derived from *σῶμα, body*.

The original price charged by Rafinesque for his small volume was 25 cents. By 1947 the work had appreciated just 100,000 per cent—a copy having been offered for sale in that year for $250. The reprint is priced at $4.00, and is obtainable from Peter Smith, 321 Fifth Avenue, New York 16.

Guillermo Hernandez de Alba has collected and edited the letters of José Celestino Mutis, the celebrated botanical explorer of the "Nuevo Reino de Granadas" (Colombia and adjacent regions). Volume 1 of the collected letters, which contains also a portrait and biographical sketch of their author, has been issued by the Ministerio de Educación Nacional at Bogotá (1947), under the title *Archivo epistolar del sabio naturalista José Celestino Mutis* (or, on the spine, *Epistolario del sabio Mutis;* the running head of the pages is *Cartas del sabio Mutis*). It forms a bulky volume of xxiii + 307 pages.

Under the title *Orchids in retrospect* the Botanical Museum of Harvard University has published a collection of the botanical writings of Oakes Ames. The essays were assembled by his colleagues as a celebration of his golden anniversary as "scholar, teacher and administrator" at Harvard. The collection embraces 14 papers, a biographical sketch with portrait, and a list of publications of the distinguished student of Orchidaceae. The papers are drawn mainly from his more popular writings. Many of the superb illustrations drawn by Blanche Ames are included. The book (xix + 172 p.) is sumptuously printed on the finest paper, bound in heavy red paper.

Reviews

Beginner's Guide to Wild Flowers. By Ethel Hickley Hausman. 376 p. G. P. Putnam's Sons, New York.

This conveniently small book is intended for "beginners," those who cannot or do not wish to use the available keys for identifying unknown plants. Here the wild flowers are divided into five color-sections. Within each section the flowers are arranged according to families. The idea, however is to thumb through the pages to find the drawing which corresponds to the flower in hand. It is further suggested that the drawing then be colored from the specimen and the paper has been selected to make this possible. This should have a real appeal to many amateurs (especially to children)—the attractiveness and usefulness of the book growing as the user becomes acquainted with more of the wild flowers. The drawings are neat and clear, showing flowers and leaves, often the entire plant. There are three on each page and 360 pages of them. Beside each is a very brief description giving common and botanical names, color variations, significant measurements, habitat, distribution, and family. The color-section heading is carried across the pages.

The reviewer tried out the book with three children 10 and 11 years of age, who gathered flowers they did not know and were successful in identifying all in a short time.—Theresa C. Rickett.

Advances in Genetics. Edited by M. Demerec. Volume 1, xvi + 458 p. 1947. Volume 2, viii + 373 p. 1948. Academic Press, New York.

Between the journal paper, with its detailed consideration of specific small segments of a general problem, and the textbook, which can perforce contain only broad outlines, there has existed a large gap in genetic publications, filled only by occasional reviews. *Advances in Genetics*, of which Volumes 1 and 2 are the first of what should be a lusty family, in which new sibs will appear annually, is a praiseworthy and successful effort to fill this breach. Its editor, M. Demerec, indicates in the preface to Volume 1 that "critical summaries of outstanding genetic problems, written by competent geneticists . . . are expected to deal with both theoretical and practical problems, and to cover plant breeding, animal breeding, and human heredity, as well as the related fields of biophysics, biochemistry, physiology, and immunology. The aim is to have the articles written in such form that they will be useful as reference material for geneticists and also as a source of information to nongeneticists." The editor is assisted by an editorial board consisting of G. W. Beadle, W. C. Boyd, Th. Dobzhansky, L. C. Dunn, M. T. Jenkins, J. L. Lush, A. Mirsky, H. J. Muller, J. T. Patterson, M. M. Rhoades, L. J. Stadler, and C. Stern.

The reviews contained in the first two volumes amply fulfill the editorial aims. In many cases the reviewers are the persons most concerned with the modern development of their field. The treatment, which necessarily varies among the various writers, is suffi-

ciently specific to afford a good grasp of details without being so much so as to obscure the essential outlines of a problem. As is to be expected, those reviews which deal with controversial topics reveal some bias toward the reviewer's own convictions. The editor is to be congratulated on his choice of topics for inclusion, striking a balance between the standard, reviewed-to-death subjects and the less well known. An adequate subject index and an author index to cited researches are provided.

In Volume 1, Sanford S. Atwood discusses cytogenetics and breeding of forage crops, reviewing the cytology, genetics, and practical breeding of the more important forage grasses and legumes. Ernest B. Babcock reviews the cytogenetic processes involved in speciation in *Crepis*. Myron Gordon discusses speciation in fishes, giving an interesting analysis of the distribution in time and space of seven dominant multiple alleles in *Platypoecilus*. In the general field of immunogenetics, M. R. Irwin reviews the work on the human cellular antigens, species relations as revealed by the antigens of doves, and the interesting antigen relations in cattle. P. C. Mangelsdorf attacks the vexing problem of the origin and evolution of maize; unfortunately he probably has not succeeded in satisfying any of the several opposing groups of doctrinaires interested in this subject. Robert R. Shrode and Jay L. Lush discuss the genetics of cattle, including the complexities of milk and beef production as well as the simpler morphological characters. The recent advances in the genetics of *Paramecium* and *Euplotes* are ably summarized by the man most responsible for them, Tracy M. Sonneborn, who points out the many possibilities of protozoa as genetic material. The occurrence and distribution of mutations in wild populations of *Drosophila* is discussed by Warren P. Spencer. G. Ledyard Stebbins, Jr. assesses the significance of polyploidy as an evolutionary process, and attempts to construct an orderly classification of the various types. The cytogenetics of *Gossypium* and the problem of origin of the New World cottons are reviewed by S. G. Stevens.

The opening review of Volume 2 is a discussion by Ernst Caspari of cytoplasmic inheritance, in which he covers a number of classical cases which have been lost to the public eye in the recent excitement over *Paramecium* and the yeasts. Gunnar Dahlberg applies to the genetics of human populations some of the concepts which have already yielded excellent results in the fruit-flies. W. E. Heston reviews the genetics of cancer. Sally Hughes-Schrader gathers together much information concerning the cytology of the coccids, a group which is a proving-ground for variations on the more common type of chromosome structure and behavior. Ernst Mayr discusses the nature of species in the light of the combined approach of the "new systematics." The cytology and genetics of the wheats and their relatives is reviewed by E. R. Sears. D. G. Catheside treats of the genetic effects of radiations.—J. R. SINGLETON.

INDEX TO AMERICAN BOTANICAL LITERATURE

COMPILED BY

LAZELLA SCHWARTEN

WITH THE COLLABORATION OF THE EDITOR OF THE TAXONOMIC INDEX

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used to include the entire Western Hemisphere.

Papers that relate exclusively to bacteriology, forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included. If users of the Index will call the attention of the Bibliographer to errors or omissions, their kindness will be appreciated.

The Index is reprinted monthly on cards, and furnished in this form to subscribers at the rate of three cents for each card. The different subjects as classified below may be ordered separately (but no orders will be taken for less than one year's issue in any classification). Correspondence relating to the card issue should be addressed to the Treasurer of the Club.

TAXONOMY, PHYLOGENY AND FLORISTICS

ALGAE

(See also under Ecology and Plant Geography: **Gessner**)

Flint, Lewis H. Studies of fresh-water red algae. Am. Jour. Bot. **35**: 428–433. *f. 1–40.* Jl [Au] 1948.

Hewitt, A. F. & Gustafson, P. V. Plankton forms of some lakes near Spokane. Northw. Sci. **21**: 168. N 1947.

Hughes, Elwyn, O. New fresh-water Chlorophyceae from Nova Scotia. Am. Jour. Bot. **35**: 424–427. *f. 1–6.* Jl [Au] 1948.

Northcroft, Richard D. Marine algal colonization on the Monterey Peninsula, California. Am. Jour. Bot. **35**: 396–404. *f. 1–6.* Jl [Au] 1948.

Tiffany, Lewis Hanford. *Oedogonium chapmanii* sp. nov. from New Zealand. Nat. Hist. Misc. **16**: 1–3. *f. 1–9.* [*pl. 1* on p. 3]. 15 Ap 1948.

FUNGI AND LICHENS

(See also under Bryophytes: **Gorham**)

Doty, Maxwell S. A preliminary key to the genera of clavarioid fungi. Bull. Chicago Acad. **8**: 173–178. 1948.

Lindquist, Juan C. Las Puccinias parásitas de *Geranium*, en la República Argentina. Notas Mus. La Plata Bot. **13**[61]: 63–70. *f. 1.* 3 Au 1948.

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Martin, G. W. Two new species of *Physarum.* Jour. Wash. Acad. **38**: 238–240. *f. 1, 2.* 15 Jl 1948.

Thomson, John W. Experiments upon regeneration of certain species of *Peltigera;* and their relationship to the taxonomy of this genus. Bull. Torrey Club **75**: 486–491. *f. 1 + table 1.* S–O 1948.

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Gorham, Eville. Bryophytes and lichens in the pastures of the Maritime Provinces. Proc. Nova Scotian Inst. **22**: 1–10. *tables 1–6*. My 1948.

Richards, P. W. The cultivation of mosses and liverworts. Trans. Brit. Bryol. Soc. **1**: 1–3. 1948.

Wigglesworth, G. Reproduction in *Polytrichum commune* L. and the significance of the rhizoid system. Trans. Brit. Bryol. Soc. **1**: 4–13. *f. 1–5*. 1948.

PTERIDOPHYTES

Reed, Clyde F. The phylogeny and ontogeny of the *Pteropsida*. Bol. Soc. Brot. II. **21**: 71–195. *pl. 1–5 + maps A–N*. 1947 [1948].

SPERMATOPHYTES

(See also under Genetics: **Bowden; Brown**)

Allard, H. A. *Vaccinium Erythrocarpum* forma *nigrum*, f. novo. Castanea **13**: 127. S [O] 1948.

Amshoff, G. J. H. Humiriaceae, Malpighiaceae [of Guiana]. *In:* Maguire, Basset *et al.*, Plant explorations in Guiana in 1944, chiefly to the Tafelberg and the Kaieteur Plateau—V. Bull. Torrey Club **75**: 523–526. S–O 1948.

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